UNCLASSIFIED

21SEP89
TBF058.FDR

DTIC
ELECTE
SEP 28 1992
S C D

AD-A257 567

92 9 25 058

TWO BEAM FUNNEL EXPERIMENT

FINAL DESIGN REVIEW

DISTRIBUTION STATEMENT A:
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION
IS UNLIMITED.

92-25907

420293

186 pg

McDonnell Douglas Missile Systems Company

UNCLASSIFIED

21SEP89
TBF058.FDR

TWO BEAM FUNNEL EXPERIMENT

FINAL DESIGN REVIEW

DTIC QUALITY INSPECTED 3

DISTRIBUTION STATEMENT A:
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION
IS UNLIMITED.

Accession For
NTIS GRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification
By
Distribution/
Availability Codes
Avail and/or
Dist Special
A-1

McDonnell Douglas Missile Systems Company

TWO-BEAM FUNNEL FINAL DESIGN REVIEW

21SEP89

MDMSC, ST. LOUIS, BLDG. 106, RM. 205

AGENDA

8:30 am	OPENING REMARKS (15 min)	USASDC
8:45 am	INTRODUCTION (30 min) - EXPERIMENT OBJECTIVES - DESIGN STATUS, SCHEDULE STATUS, SUMMARY	ARD MDMSC
9:15 am	PHYSICS DESIGN (60 min) - MAGNETIC OPTICS DESIGN STATUS, ACTION ITEMS - MAGNET PROCUREMENT STATUS, MAGNET Q/A - THERMO-MECHANICAL ANALYSES	SCHMITT MDMSC
10:15 am	ACCSYS ACTIVITIES (45 min) - SINGLE HOLE REBUNCHER STATUS, ACTION ITEMS - FUNNEL SENSITIVITY ANALYSIS - ACCELERATOR STATUS	CRANDALL AccSys
11:00 am	RF COMPONENTS (60 min) - TWO HOLE REBUNCHER/RF DEFLECTOR STATUS, A/I - RF POWER SUPPLY STATUS, ACTION ITEMS	POTTER AccSys
12:00 noon	LUNCH/FACILITY INSPECTION	
1:30 pm	ENGINEERING DESIGN (45 min) - ACCELERATOR/FUNNEL BEAMLINE INTERFACE - FUNNEL BEAMLINE/VACUUM CHAMBER DESIGN - ACTION ITEMS	PAPA MDMSC
2.15 pm	FACILITY STATUS (30 min)	LOWELL MDMSC
2:45 pm	DIAGNOSTICS/DATA ACQUISITION (60 min)	BALLOU MDMSC
3:45 pm	EXPERIMENT PLAN (45 min) - MASTER SCHEDULE - BUILDUP ACTIVITIES - EXPERIMENT SEQUENCE	ARD MDMSC
4:30 pm	ADJOURN	

TBFFDR.AGENDA
21SEP89

TBF EXPERIMENT PLAN

MAJOR OBJECTIVE

- DEMONSTRATE INCREASED BEAM BRIGHTNESS FROM FUNNELING BEAM FROM TWO SEPARATE ACCELERATORS

OTHER OBJECTIVES

- EVALUATE CONTRIBUTION TO EMITTANCE GROWTH DUE TO THE RF DEFLECTOR
- EVALUATE EFFECTS OF REBUNCHING ON CONTROL OF EMITTANCE GROWTH
- EVALUATE USE OF STRIPLINE POSITION AND PHASE DETECTORS FOR USE IN AUTOMATIC CONTROL OF FUNNEL PARAMETERS

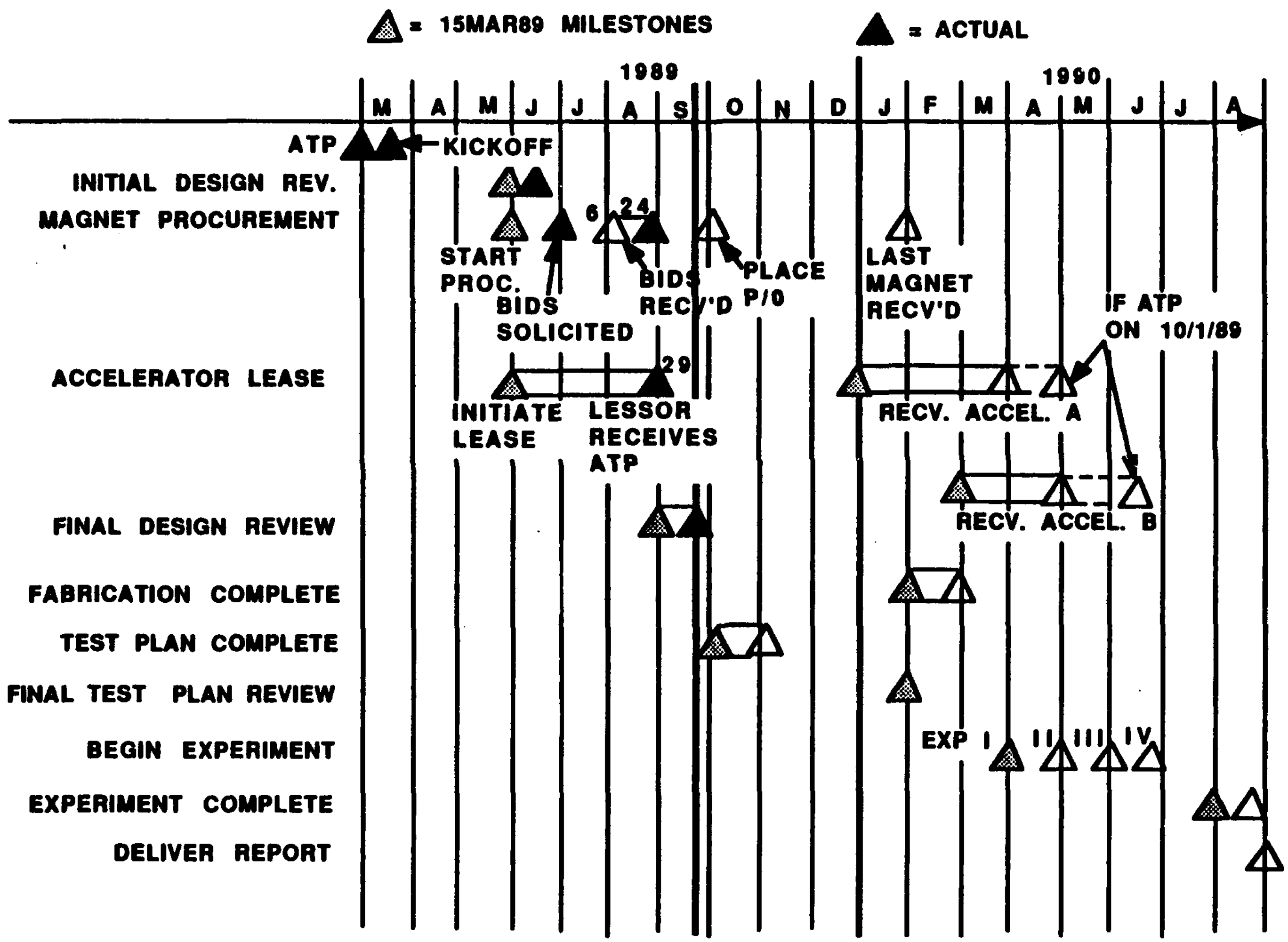
TBF ACTION ITEMS

1. QUALITY ASSURANCE FOR MAGNETS —— SCHMITT
2. BEAMLINE ERROR AND SENSITIVITY ANALYSIS (AccSys ACTIVITY) —— CRANDALL
3. MICROSTRIP PROBES —— BALLOU
4. LANL EMITTANCE SCANNER SOFTWARE —— BALLOU
5. VACUUM VESSEL DESIGN —— PAPA
6. BEAM STEERING VIA OFFSET QUADRUPOLES (AccSys ACTIVITY) —— CRANDALL
7. REBUNCHER/RF DEFLECTOR DESIGNS —— POTTER
8. RF SYSTEM CONTROLS —— POTTER
9. REBUNCHER/RF DEFLECTOR THERMAL ANALYSIS —— SCHMITT
10. RIGHT/LEFT BEAM EMITTANCES —— SCHMITT
11. COPPER-COATED ALUMINUM RF CAVITY DETAILS —— POTTER
12. LEBT DESIGN —— CRANDALL

PROCUREMENT STATUS

- MAGNET P.O. TO BE PLACED BY 9/29/89
- VACUUM VESSEL OUT FOR QUOTES. BIDS CLOSE 10/13/89
- EMITTANCE SCANNER TRANSLATORS IN QUOTE CYCLE
- EMITTANCE SCANNER SLIT, COLLECTOR AND BEAMSTOP ASSEMBLIES RELEASE FOR QUOTE 9/25/89
- STEERING QUAD TRANSLATORS RELEASE FOR QUOTE 9/25/89
- CAMAC INSTRUMENTATION RELEASE FOR QUOTES 9/25/89
- VACUUM FEEDTHRUS RELEASE FOR QUOTES 9/29/89
- BEAM CURRENT TOROIDS RELEASE FOR QUOTES 9/29/89

TBFE MILESTONES



McDonnell Douglas Missile Systems Company

PHYSICS DESIGN

RAY SCHMITT

PHYSICS DESIGN - ACTION ITEMS

1. QUALITY ASSURANCE FOR MAGNETS
2. BEAMLINE ERROR AND SENSITIVITY ANALYSIS (AccSys ACTIVITY)
3. MICROSTRIP PROBES
4. LANL EMITTANCE SCANNER SOFTWARE
5. VACUUM VESSEL DESIGN
6. BEAM STEERING VIA OFFSET QUADRUPOLES (AccSys ACTIVITY)
7. REBUNCHER/RF DEFLECTOR DESIGNS
8. RF SYSTEM CONTROLS
9. REBUNCHER/RF DEFLECTOR THERMAL ANALYSES
10. RIGHT/LEFT BEAM EMITTANCES
11. COPPER-COATED ALUMINUM RF CAVITY DETAILS
12. LEBT DESIGN

13. Q11 OPTIMIZATION FOR LOWER EMITTANCE GROWTH
14. EMITTANCE GROWTH IN RF DEFLECTOR
15. FLOOR COORDINATES
16. MAGNET PROCUREMENT STATUS

MAGNET PROCUREMENT STATUS

- BIDS RECEIVED FROM THREE VENDORS (DUE 24AUG89)
  - DEXTER/PERMAG
  - IGC/FIELD EFFECTS
  - MAXWELL/BROBECK
- ALL VENDOR BIDS WERE RESPONSIVE
- TECHNICAL EVALUATION COMPLETED 6SEP89
- WINNER TO BE ANNOUNCED NEXT WEEK
  (SEALED BID FAR'S STILL APPPLY TODAY)
- 120 DAY DELIVERY SCHEDULE
  (90 - 150 DAY INCREMENTAL DELIVERY SCHEDULE IS FEASIBLE)

MAGNET IDENTIFICATION AND LAYOUT

THE TBF LATTICE REQUIRES NINE QUADRUPOLES AND TWO DIPOLES IN EACH OF THE RIGHT AND LEFT BEAMLINES AND TWO QUADRUPOLES IN THE COMMON SECTION OF THE FUNNEL. THE QUADRUPOLES AND DIPOLES ARE 16-SEGMENT HALBACH-TYPE RING MAGNET DESIGNS USING SAMARIUM-COBALT MATERIAL. THE RIGHT AND LEFT BEAMLINES EACH CONTAIN TWO 425 MHz REBUNCHER CAVITIES. THE 425 MHz RF DEFLECTOR IS LOCATED IN THE COMMON FUNNEL SECTION BETWEEN QUADRUPOLES Q10 AND Q11. QUADRUPOLE Q11 IS ADJUSTED TO PRODUCE AN OUTPUT BEAM WITH ~ 1.0 deg. DIVERGENCE ANGLE FOR USE BY THE EMITTANCE SCANNER.

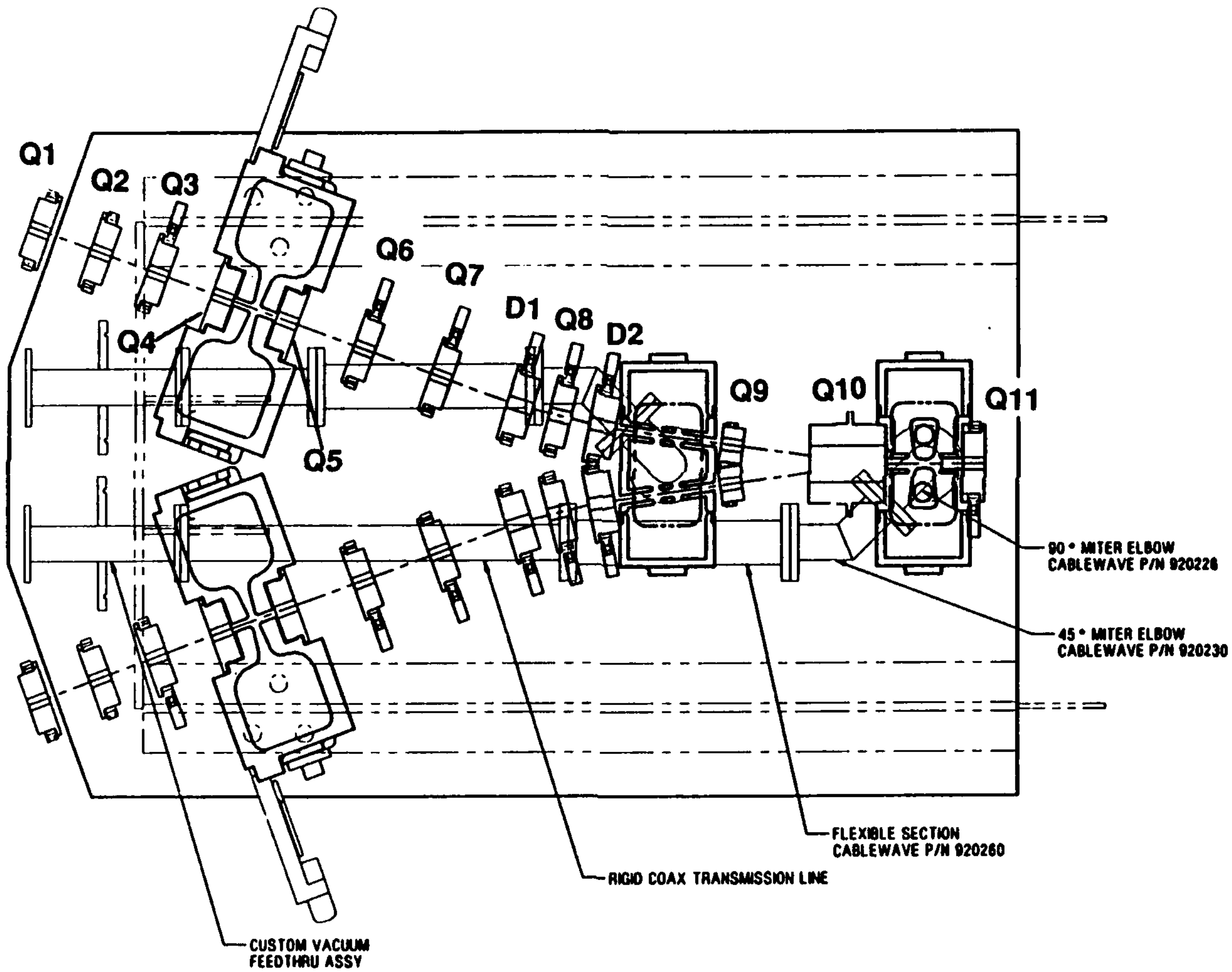
THE TOTAL LENGTH OF THE TBF BEAMLINE FROM Q1 THROUGH Q11 IS ~ 1.3m. THE LATERAL SEPARATION OF THE TBF RIGHT AND LEFT BEAMLINES IS ~ 55cm AT THE RFQ OUTPUT PLANE.

THE TOTAL BEND ANGLE OF EACH FUNNEL LEG IS 20 deg WITH THE DIPOLES PROVIDING 12 deg AND THE BALANCE PROVIDED BY QUADRUPOLE Q10 AND BY THE RF DEFLECTOR (~ 5 deg BY Q10 AND ~ 3 deg BY THE DEFLECTOR).

THE SINGLE-HOLE REBUNCHER, G1, IS LOCATED BETWEEN Q4 AND Q5 AND OPERATES AT 120 kV EFFECTIVE GAP VOLTAGE. THE TWO-HOLE REBUNCHER, G2, LOCATED BETWEEN D2 AND Q9, HAS 152 kV EFFECTIVE GAP VOLTAGE. THE RF DEFLECTOR PRODUCES 3.14 deg DEFLECTION ANGLE AND REQUIRES 211 kV ACROSS A 10 mm GAP.

21SEP89
TBF068.FDR

MAGNET IDENTIFICATION AND LAYOUT



McDonnell Douglas Missile Systems Company

RF DEFLECTOR GEOMETRY

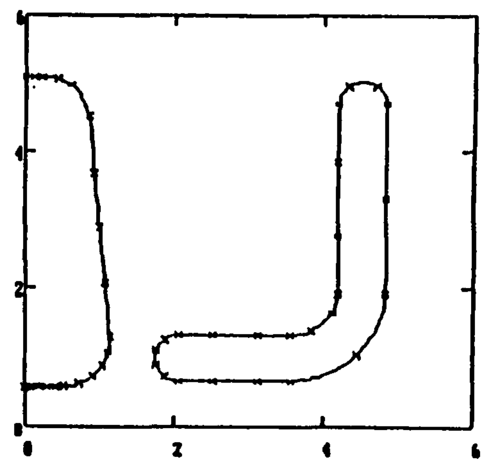
THE FIGURE SHOW THE RF DEFLECTOR BASELINE FOR THE TBF EXPERIMENT. THE "L-NOSE" CONFIGURATION, DISCUSSED IN THE JUNE REVIEW, REMAINS THE BASELINE. THIS GEOMETRY SHOWS LOW OVERALL CAPACITANCE (~ 4pF) AND ACCEPTABLE FRINGE FIELD FALLOFF.

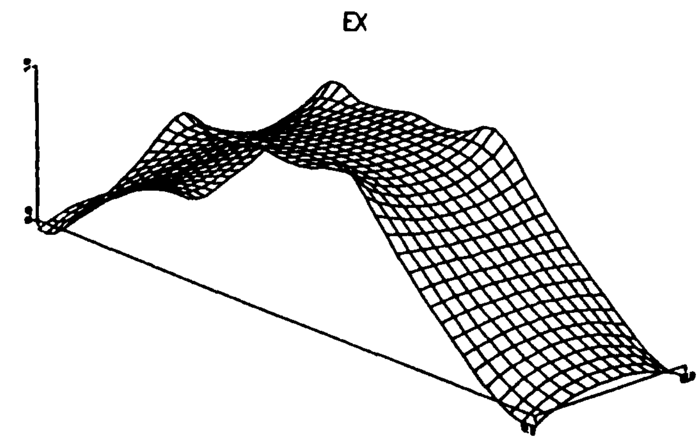
THE PLOTS SHOW THE ELECTRIC FIELD COMPONENTS $E_x(x,z)$ AND $E_z(x,z)$ PLOTTED AS A FUNCTION OF x AND z.

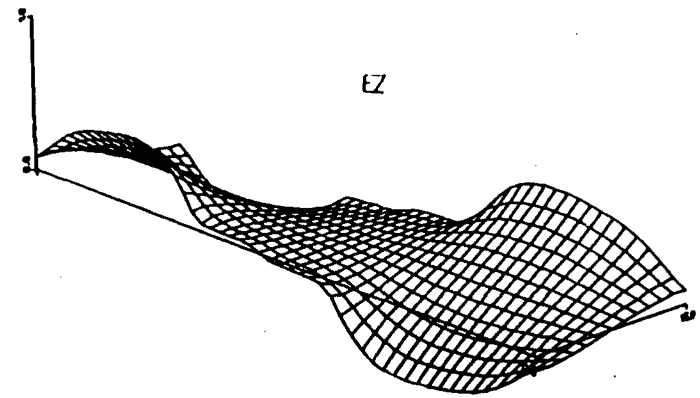
21SEP89
TBF070.FDR

RF DEFLECTOR GEOMETRY

L-NOSE







RMS BEAM ENVELOPES - 15JUN89 REVIEW

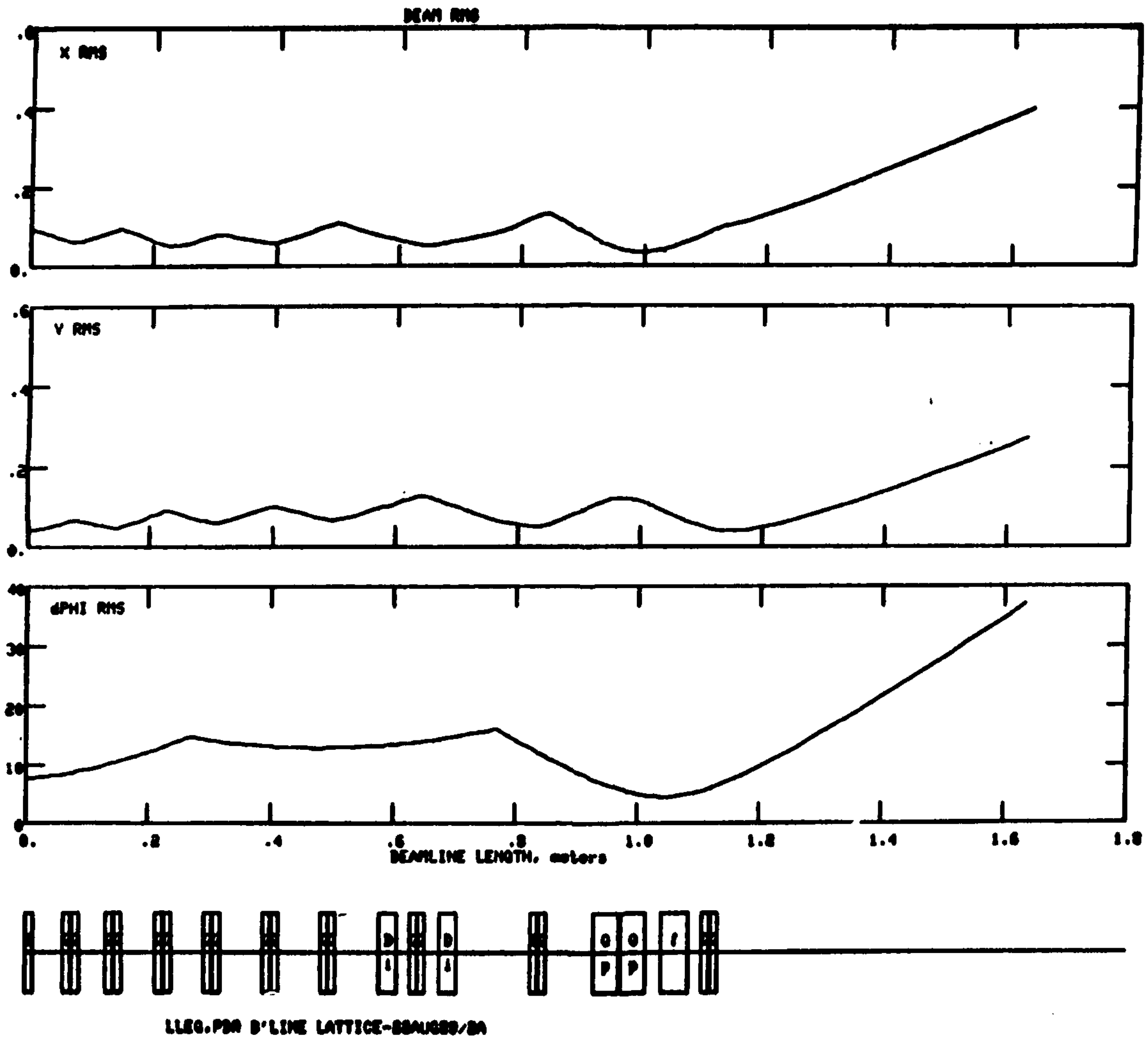
THE FIGURE SHOW THE RMS BEAM ENVELOPES FOR THE PREVIOUS TBF BASELINE LATTICE. THE UNITS ARE [cm] FOR X AND Y AND [deg] FOR dPHI. THE ENVELOPES FOR THE ENTIRE BEAM ARE 2.25 TIMES LARGER THAN THE RMS VALUES.

DOWNSTREAM FROM THE LAST QUADRUPOLE MAGNET, Q11, THE BEAM EXPANDS IN BOTH THE X-Z AND Y-Z PLANES (Q11 = 2.8kG) AND IN THE VICINITY OF THE EMITTANCE SCANNER INPUT SLIT (z ~ 1.2m), THE X AND Y ENVELOPES ARE BOTH ~ 1mm +/- 0.5mm RMS RADIUS.

WITH Q11 = 2.8kG, THE FOCUSING IS WEAK DOWNSTREAM FROM Q11 AND PRODUCES RELATIVELY LARGE (X-X') EMITTANCE GROWTH (~20%) IN THIS PART OF THE BEAMLINE.

21SEP89
TBF005.FDR

RMS BEAM ENVELOPES - 15JUN89 REVIEW



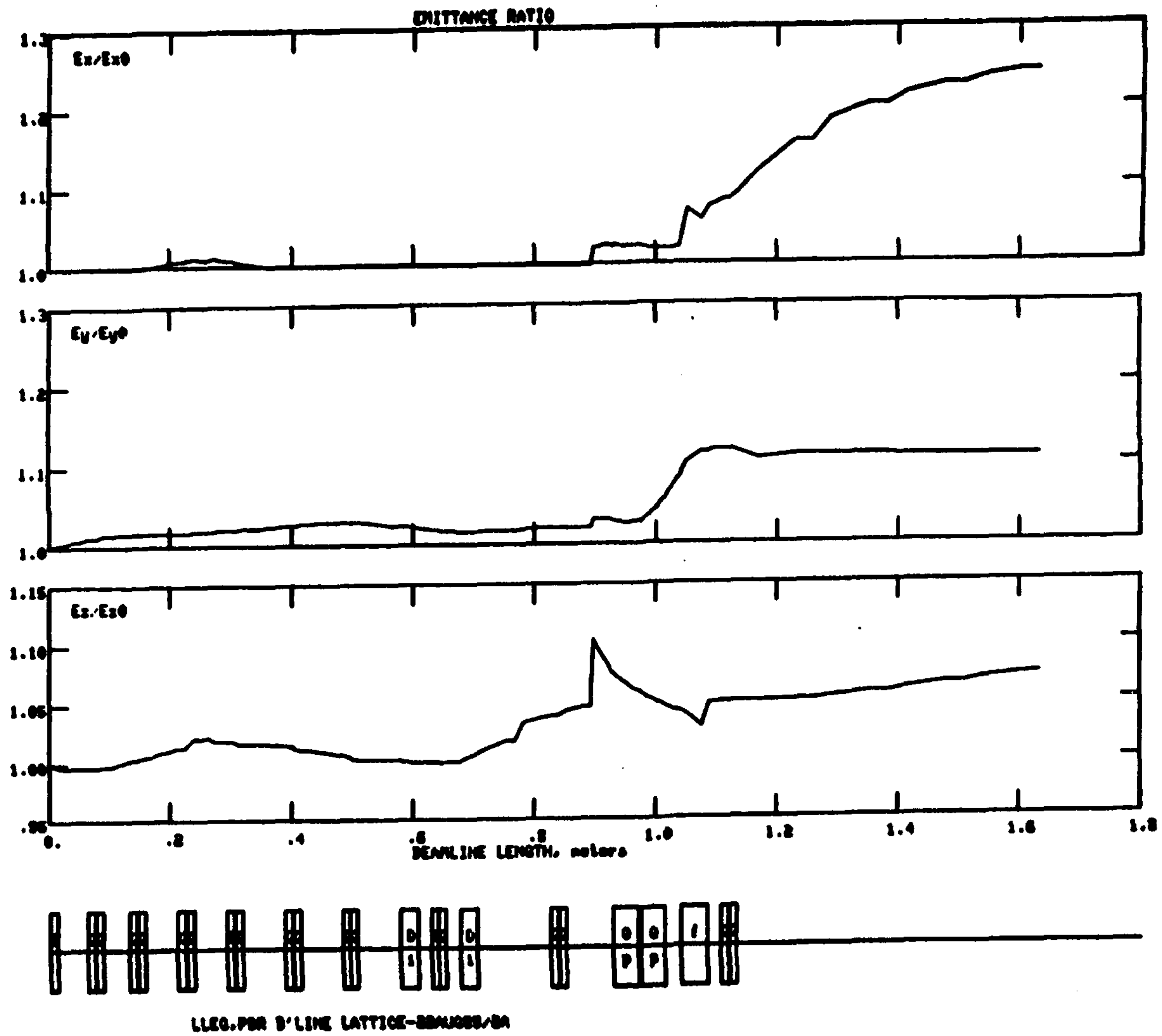
McDonnell Douglas Missile Systems Company

EMITTANCE GROWTH - 15JUN89 REVIEW

THE FIGURE SHOWS THE EMITTANCE GROWTH AS A FUNCTION OF POSITION IN THE BEAMLINE FOR THE PREVIOUS TBF BASELINE LATTICE. EMITTANCE GROWTH IS THE RATIO OF RMS EMITTANCE AT POSITION z TO THE CORRESPONDING VALUE AT z=0 (i.e. AT THE MIDPLANE OF Q1, THE FIRST QUADRUPOLE IN THE LATTICE). WITH Q11 = 2.8kG, THE EMITTANCE GROWTH IN THE (x-x') PLANE SHOWS A STEADY INCREASE IN THE REGION DOWNSTREAM FROM THE LAST QUADRUPOLE, Q11. THIS IS DUE TO THE WEAK FOCUSING PROVIDED BY Q11.

NOTE: THE SPIKES IN THE (z-z') ARE ANOMALIES OF THE OPTICS CODE AND DO NOT REPRESENT REAL PHENOMENA.

EMITTANCE GROWTH - 15JUN89 REVIEW



McDonnell Douglas Missile Systems Company

LATTICE OPTIMIZATION - FINAL FODO PERIOD

THE TBF BASELINE LATTICE AT THE 15JUN89 REVIEW SHOWED ~20% EMITTANCE GROWTH IN THE (x-x') PLANE DOWNSTREAM FROM THE FINAL QUADRUPOLE MAGNET, Q11. THIS EMITTANCE GROWTH CAN BE REDUCED BY OPTIMIZING THE POLE TIP FIELDS OF QUADRUPOLES Q10 AND Q11 AND THE RF DEFLECTOR VOLTAGE. THE 'TRAVEL' OPTICS DESIGN CODE WAS IMPROVED TO DO THIS OPTIMIZATION AUTOMATICALLY USING THIS CODE'S UNCONTRAINED MINIMIZING OPTIMIZER. THE OPTIMIZER FOUND THE VALUES WHICH PRODUCE CENTROID VALUES Xc <0.001cm and Xc' <0.001milliradian. THE FIGURE SHOWS THE EMITTANCE GROWTHS AS A FUNCTION OF Q11 POLE TIP FIELD.

CHOOSING Q11 = 10kG PRODUCES SATISFACTORY EMITTANCE GROWTHS

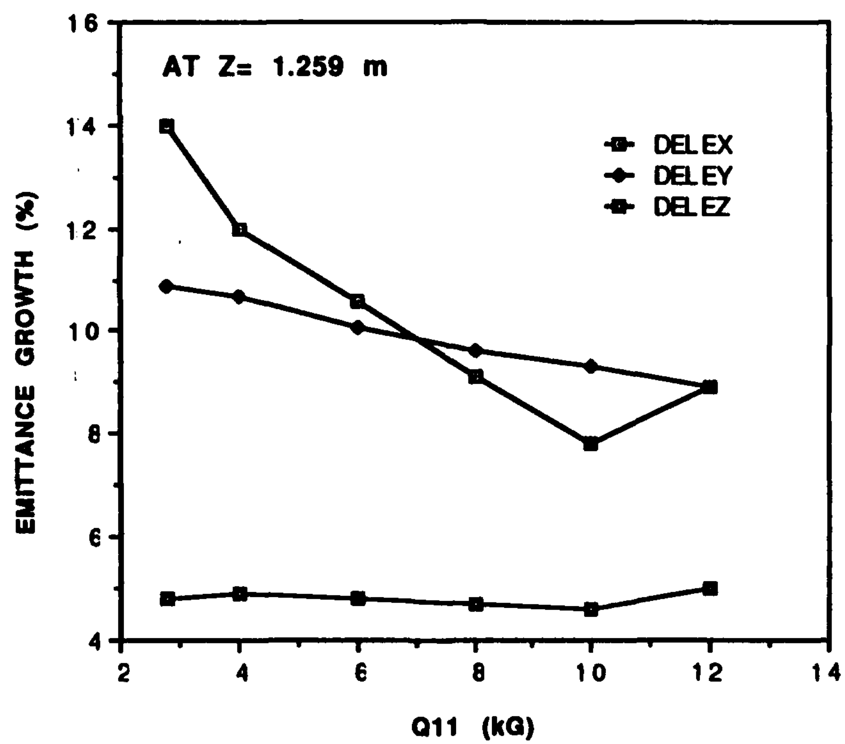
$$\left\{\begin{array}{l} \Delta\varepsilon_x = 7.8\% \\ \Delta\varepsilon_y = 9.3\% \quad \text{(at } Z = 1.259\text{m)} \\ \Delta\varepsilon_z = 4.6\% \end{array}\right.$$

THE OLD AND NEW VALUES FOR Q10 FIELD AND RF DEFLECTOR VOLTAGE ARE AS FOLLOWS:

15JUN89 REVIEW	21SEP89 REVIEW
Q10 = -7.0407 kG	Q10 = -6.908587 kG
V_{rfdfl} = 202.3 kV	V_{rfdfl} = 211.3 kV

LATTICE OPTIMIZATION - FINAL FODO PERIOD

OPTIMIZED EMITTANCE GROWTH vs Q11 FIELD



TBF001.FDR

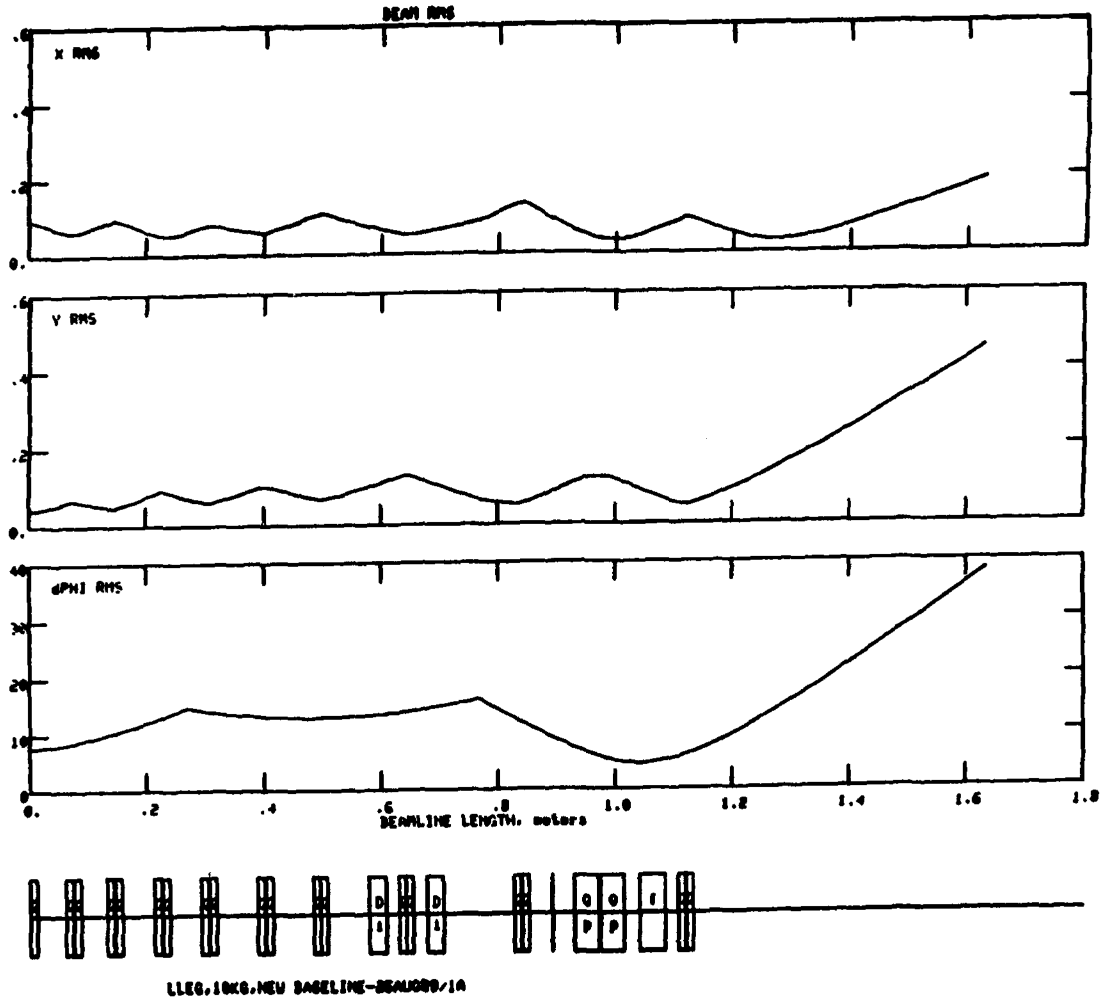
McDonnell Douglas Missile Systems Company

RMS BEAM ENVELOPES - 21SEP89 REVIEW

THE FIGURE SHOWS THE RMS BEAM ENVELOPES FOR THE REVISED TBF BASELINE LATTICE. THE UNITS ARE [cm] FOR X AND Y AND [deg] FOR dPHI. THE ENVELOPES FOR THE ENTIRE BEAM ARE 2.25 TIMES LARGER THAN THE RMS VALUES.

WITH Q11 = 10kG, STRONG FOCUSING IS OBTAINED IN THE (X-X') PLANE AND THE BEAM SHOWS A MINIMUM IN THE X ENVELOPE AROUND Z=1.3m. THE EMITTANCE SCANNER INPUT SLITS CAN BE LOCATED A SHORT DISTANCE DOWNSTREAM OF Q11 (AT Z ~ 1.2m) AT WHICH POSITION THE RMS X AND Y ENVELOPES ARE IN THE 0.5 TO 1mm RANGE. NOTE THAT AT THIS LOCATION, X IS FOCUSING AND Y IS DEFOCUSING. THIS IS THE CORRECT BEAM CONDITION FOR MATCHING THE FUNNEL OUTPUT BEAM TO THE DOWNSTREAM LINAC.

RMS BEAM ENVELOPES - 21SEP89 REVIEW



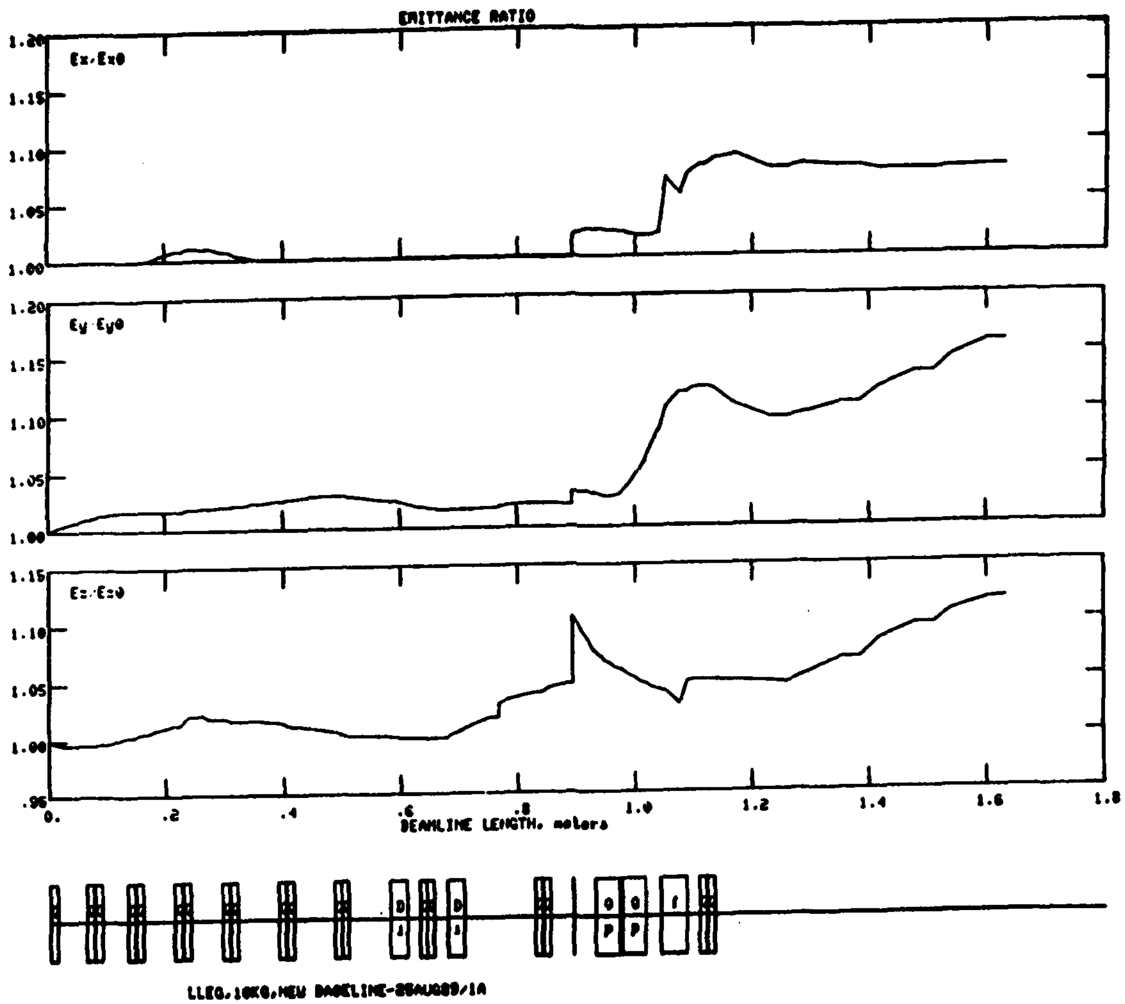
McDonnell Douglas Missile Systems Company

EMITTANCE GROWTH - 21SEP89 REVIEW

THE FIGURE SHOWS THE EMITTANCE GROWTH AS A FUNCTION OF POSITION IN THE BEAMLINE FOR THE REVISED LATTICE. WITH Q11 = 10kG, ALL THREE PLANES SHOW EMITTANCE GROWTHS ~10% IN THE REGION DOWNSTREAM FROM Q11. THE MONOTONIC INCREASE IN THE X EMITTANCE GROWTH, NOTICED WITH Q11 = 2.8kG, HAS BEEN ELIMINATED IN THE FUNNEL OUTPUT REGION.

IT IS SEEN THAT THE LARGEST PART OF THE X AND Y EMITTANCE GROWTHS OCCURS IN THE LAST FODO PERIOD, IN THE VICINITY OF THE DEFLECTION QUADRUPOLE (Q10) AND THE RF DEFLECTOR. IGNORING THE SPIKE ANOMALY IN THE (Z-Z') PLANE EMITTANCE GROWTH, THE CALCULATION SHOWS VERY LITTLE Z-PLANE EMITTANCE GROWTH IN THE REGION OF Q10 AND THE RF DEFLECTOR. IN EFFECT, THIS PARTICULAR LATTICE BASELINE DESIGN HAS RESULTED IN AN OPTIMIZED Z-PLANE EMITTANCE GROWTH AT THE SACRIFICE OF APPRECIABLE EMITTANCE GROWTHS IN THE X AND Y PLANES.

EMITTANCE GROWTH - 21SEP89 REVIEW



McDonnell Douglas Missile Systems Company

TBF NORMALIZED EMITTANCE

THE TABLE SHOWS THE NORMALIZED AND UNNORMALIZED EMITTANCES AT SEVERAL LOCATIONS IN THE TBF BEAMLINE. THE FOLLOWING RELATIONS ARE USED TO GENERATE THESE DATA:

$$\varepsilon_{normalized} = \beta\gamma \bullet \varepsilon_{unnormalized}$$

$$\varepsilon_{total} = 5 \bullet \varepsilon_{rms}$$

TBF NORMALIZED EMITTANCE

$T_o = 2$ MeV $E_R = 938.23$ MeV

$\gamma = 1.0021317$ $\beta = 0.065190$ $\beta\gamma = 0.065329$

		RMS, UNNORMALIZED (π cm•mrad)		RMS, NORMALIZED (π cm•mrad)		TOTAL, NORMALIZED (π cm•mrad)	
LOCATION	**Z(m)**	ε_x	ε_y	ε_x	ε_y	ε_x	ε_y
Q1 MIDPLANE	0	0.1461	0.1511	0.00954	0.00987	0.0477	0.0494
RF DEFLECTOR INPUT	1.040	0.1492	0.1636	0.00974	0.0107	0.0487	0.0534
RF DEFLECTOR OUTPUT	1.088	0.1567	0.1685	0.01023	0.0110	0.0512	0.0550

TWO BEAM FUNNEL LATTICE

THE FIGURE SHOWS THE IMPORTANT DATA FOR THE TBF LATTICE. THE FIRST FUNNEL FODO PERIOD IS A MATCHING SECTION BETWEEN THE RFQ AND THE FUNNEL LATTICE. THE SECOND PERIOD PROVIDES THE NECESSARY PHYSICSAL SPACING FOR THE SINGLE HOLE REBUNCHER, G1. THE THIRD FODO PERIOD IS A MATCHING SECTION TO THE LONG FOURTH PERIOD WHICH CONTAINS THE TWO DIPOLES AND THE TWO HOLE REBUNCHER, G2. THE FINAL FODO PERIOD, V, HAS SHORTER LENGTH AND CONTAINS DEFLECTION QUADRUPOLE, Q10, AND THE RF DEFLECTOR.

THE CHANGES FROM THE 15JUN89 REVIEW ARE AS FOLLOWS:

- Q10 HAS BEEN SLIGHTLY DECREASED FROM -7.04 kG TO -6.91 kG.

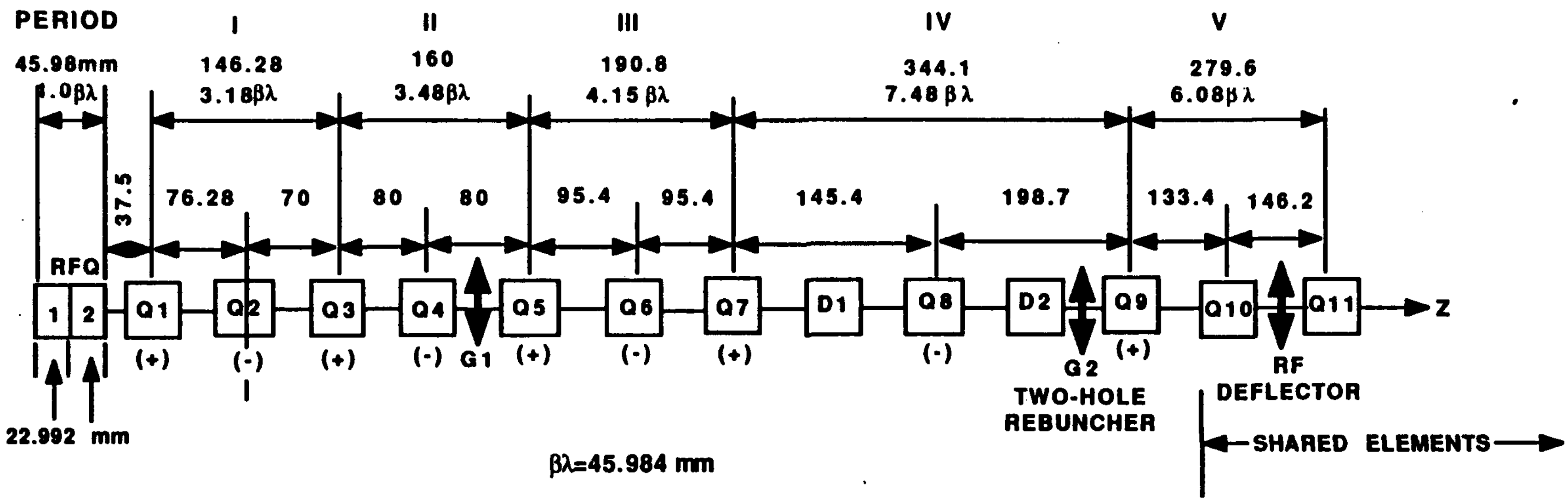
- Q11 HAS BEEN CHANGED FROM 2 8 kG TO 10.0 kG.

THE BETATRON PHASE SHIFTS ARE SHOWN FOR EACH PERIOD. THESE ARE CALCULATED USING THE BASIC DEFINITION,

$$\mu = \int_a^b \frac{dl}{\beta}$$

21SEP89
TBF013.FDR

TWO BEAM FUNNEL LATTICE

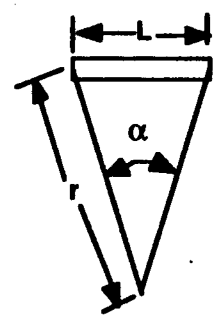


$\beta\lambda = 45.984$ mm

BETATRON PHASE SHIFT

PERIOD	μ_x (deg)	μ_y (deg)	μ_z (deg)
I	19.9	39.6	16.3
II	28.9	27.6	8.4
III	28.0	24.7	9.2
IV	49.1	46.2	15.5
V	79.0	38.8	74.2

Q1	= 10.00 kG
Q2	= -9.20 kG
Q3	= 9.20 kG
Q4	= -9.20 kG
Q5	= 7.20 kG
Q6	= -6.80 kG
Q7	= 6.80 kG
Q8	= -5.60 kG
Q9	= 8.00 kG
Q10	= -6.91 kG
Q11	= 10.00kG



$\alpha = 6$ deg
$r = 286.32$ mm

$$L = 2r \sin \frac{\alpha}{2}$$

$L = 30$ mm

$$B = \frac{[B\rho]}{r} = \frac{20.445 \text{ T-cm}}{28.632 \text{ cm}} = 7.1406 \text{ kG}$$

McDonnell Douglas Missile Systems Company

FUNNEL OUTPUT BEAM CENTROIDS

THE FIGURE SHOWS TWO WAYS THAT HAVE BEEN USED SO FAR TO OPTIMIZE THE TBF BEAM CENTROIDS AT THE FUNNEL OUTPUT.

METHOD #1, SHOWN ON THE LEFT IN THE FIGURE, USES A BEAM CONSISTING OF 1000 RAYS IN THE LEFT LEG OF THE FUNNEL AND IS CALLED THE 'ERECT' BEAM. THE BEAM USED IN THE RIGHT FUNNEL LEG IS THE MIRROR IMAGE OF THE ERECT BEAM OBTAINED BY APPLYING THE FOLLOWING TRANSFORMATION:

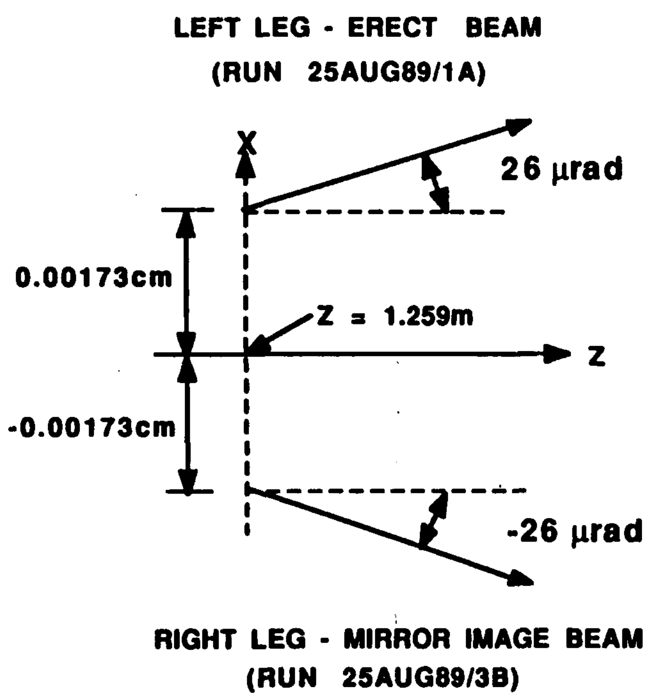
$$x \rightarrow -x \quad x' \rightarrow -x' \quad y \rightarrow -y \quad y' \rightarrow -y'$$

THIS TRANSFORMATION REMOVES THE EFFECTS OF THE INEVITABLE NON-ZERO VALUES OF THE CENTROID COORDINATES OF THE INPUT BEAM WHICH IS GENERATED VIA A RANDOM SELECTION PROCESS. CODES SUCH AS 'PARMILA' AND 'PATH/TRAVEL' USE THIS TYPE OF BEAM GENERATION PROCESS.

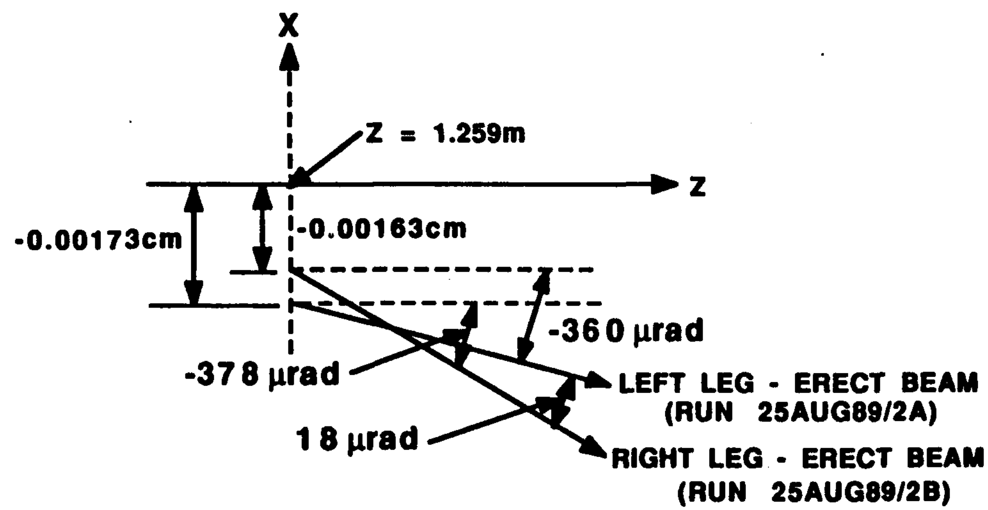
THIS RESULTS IN COMPLETELY SYMMETRICAL SOLUTIONS FOR THE TWO LEGS OF THE FUNNEL BEAMLINE USING OPTIMIZED VALUES OF Q10 AND RF DEFLECTOR VOLTAGE OBTAINED VIA THE ERECT BEAM IN THE LEFT LEG. THE EMITTANCE GROWTHS ARE IDENTICAL IN THE TWO FUNNEL LEGS.

METHOD #2, SHOWN ON THE RIGHT, USES THE ERECT BEAM IN BOTH LEGS OF THE FUNNEL AND OPTIMIZES THE BEAM CENTROIDS SEPARATELY IN THE TWO LEGS. THE AVERAGE VALUES OF Q10 AND THE RF DEFLECTOR VOLTAGE ARE USED AS THE OPTIMIZED VALUES FOR BOTH FUNNEL LEGS. THIS RESULTS IN A FUNNEL OUTPUT BEAM IN WHICH THE TWO BEAMS ARE WELL ALIGNED WITH RESPECT TO EACH OTHER, BUT WHICH SHOW FAIRLY LARGE ANGULAR OFFSETS WITH RESPECT TO THE z-AXIS. ALSO THE EMITTANCE GROWTHS ARE DIFFERENT IN THE TWO FUNNEL LEGS.

FUNNEL OUTPUT BEAM CENTROIDS



	LEFT	RIGHT
$\Delta\varepsilon_x$	7.8%	7.8%
$\Delta\varepsilon_y$	9.3%	9.3%
$\Delta\varepsilon_z$	4.6%	4.6%

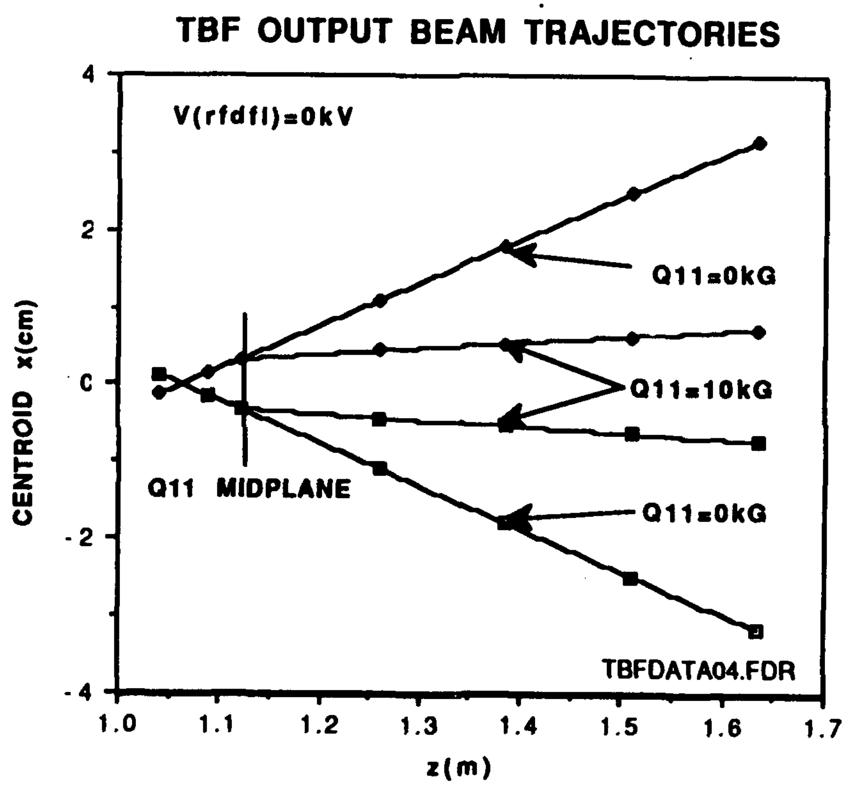


	LEFT	RIGHT
$\Delta\varepsilon_x$	7.9%	15.4%
$\Delta\varepsilon_y$	9.2%	10.0%
$\Delta\varepsilon_z$	4.6%	3.4%

TBF OUTPUT BEAM CONFIGURATION

THE FIGURE SHOWS THE x-COORDINATE OF THE TBF OUTPUT BEAMS AS A FUNCTION OF z. WITH THE LAST QUADRUPOLE, Q11, REMOVED AND THE RF DEFLECTOR VOLTAGE SET EQUAL TO ZERO, THE TWO TBF BEAM CENTROIDS EXIT THE TBF BEAMLINE AT ~3.15deg WITH RESPECT TO THE z-AXIS. WITH QUAD Q11 IN POSITION AND WITH ZERO RF DEFLECTOR VOLTAGE, THE ANGLE IS REDUCED TO ~0.44deg. A FLUORSCENT PLATE PLACED AT z=1.5m WOULD SHOW TWO SPOTS SEPARATED BY ~4.5cm IF Q11 IS REMOVED, AND ~1.5cm IF Q11 IS IN POSITION.

TBF OUTPUT BEAM CONFIGURATION



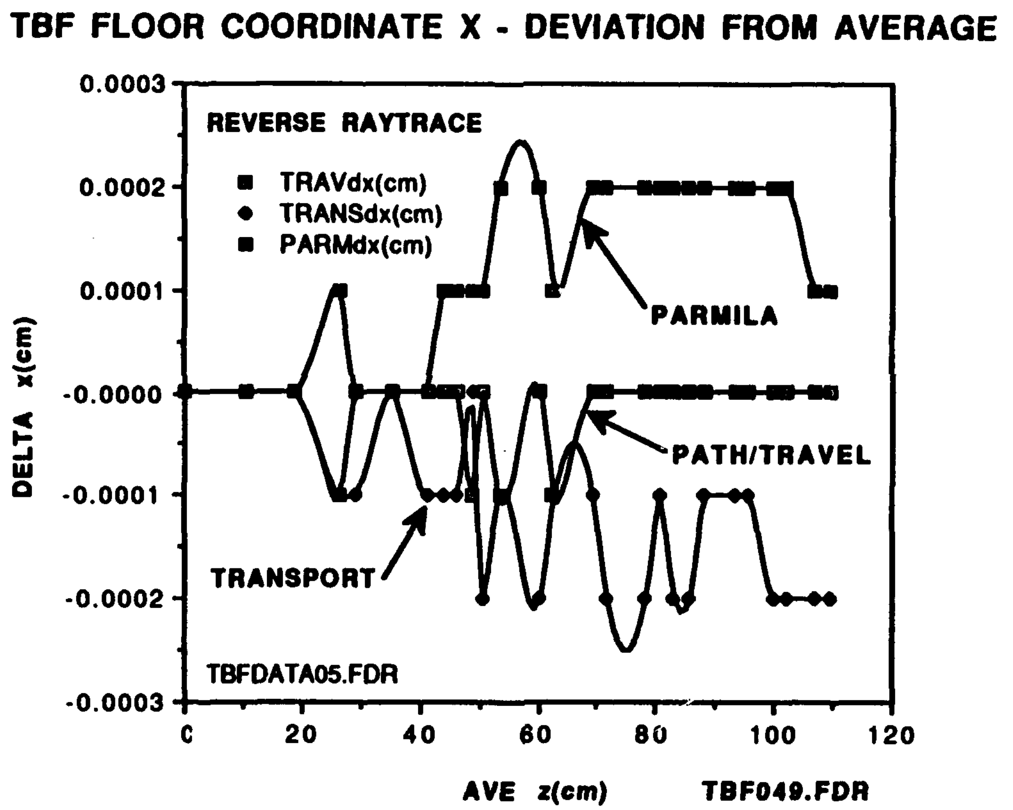
McDonnell Douglas Missile Systems Company

TBF FLOOR COORDINATE X - CODE RESULTS

THE FIGURE SHOWS THE TBF FLOOR COORDINATE X CALCULATIONS FROM THE CODES 'PARMILA', 'PATH/TRAVEL' AND 'TRANSPORT'. THE FLOOR COORDINATES ARE DETERMINED BY A REVERSE RAYTRACE THROUGH THE TBF BEAMLINE. THE ORIGIN OF FLOOR COORDINATES IS TAKEN AS THE MIDPOINT OF THE LAST QUADRUPOLE MAGNET, Q11. THE Z-AXIS POINTS ALONG THE AXIS OF Q11 IN THE DIRECTION OF THE RF DEFLECTOR. THE TBF BEAMLINE LIES IN THE X-Z PLANE. CONSEQUENTLY, THE Y FLOOR COORDINATE IS ZERO EVERYWHERE. THE FLOOR COORDINATE (X,Y,Z) VALUES ARE THE IDEAL LOCATIONS FOR THE TBF BEAMLINE COMPONENTS. THESE COORDINATES ARE ESTABLISHED DURING ASSEMBLY OF THE TBF BEAMLINE VIA THE LASER THEODOLITE.

THE PLOTS SHOW THE DEVIATIONS OF THE X FLOOR COORDINATE FROM THE AVERAGE X VALUES DETERMINED USING THE THREE DESIGN CODES. ALL THREE CODES GIVE THE SAME X VALUES TO WITHIN +/- 3 microns.

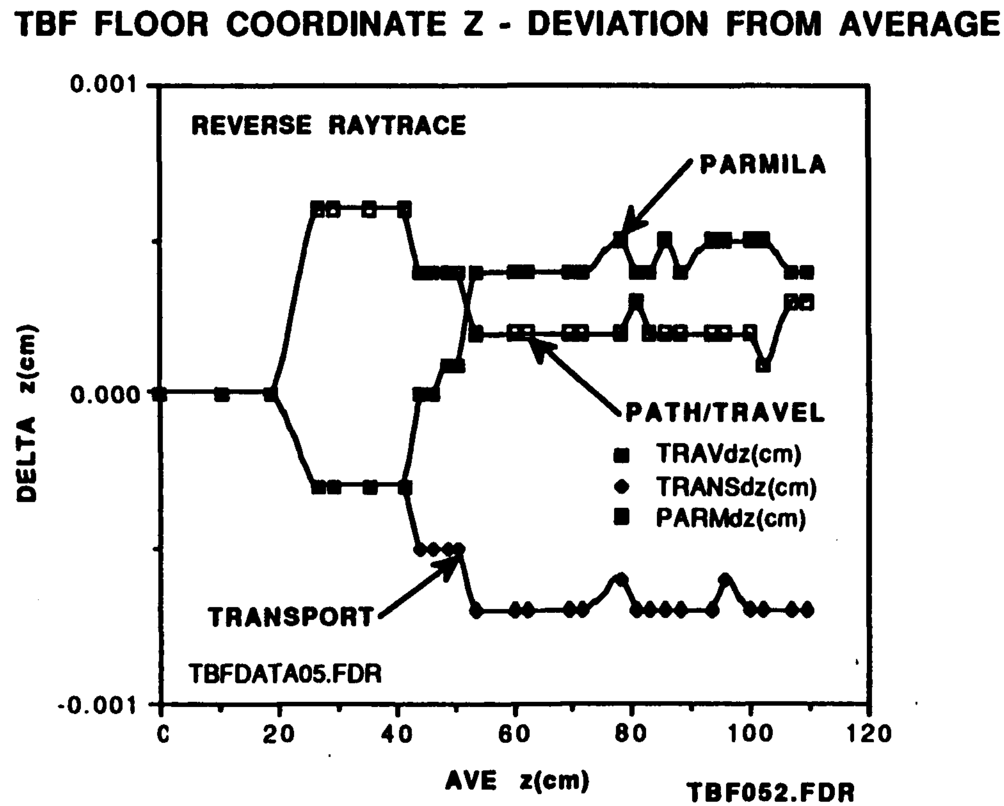
TBF FLOOR COORDINATE X - CODE RESULTS



TBF FLOOR COORDINATE Z - CODE RESULTS

THE FIGURE SHOWS THE TBF FLOOR COORDINATE Z CALCULATIONS FROM THE CODES 'PARMILA', 'PATH/TRAVEL' AND 'TRANSPORT'. THE PLOTS SHOW THE DEVIATIONS OF THE Z FLOOR COORDINATE FROM THE AVERAGE Z VALUES DETERMINED USING THE THREE DESIGN CODES. ALL THREE CODES AGREE TO WITHIN +/- 7 microns.

TBF FLOOR COORDINATE Z - CODE RESULTS



McDonnell Douglas Missile Systems Company

RF DEFLECTOR EMITTANCE GROWTH

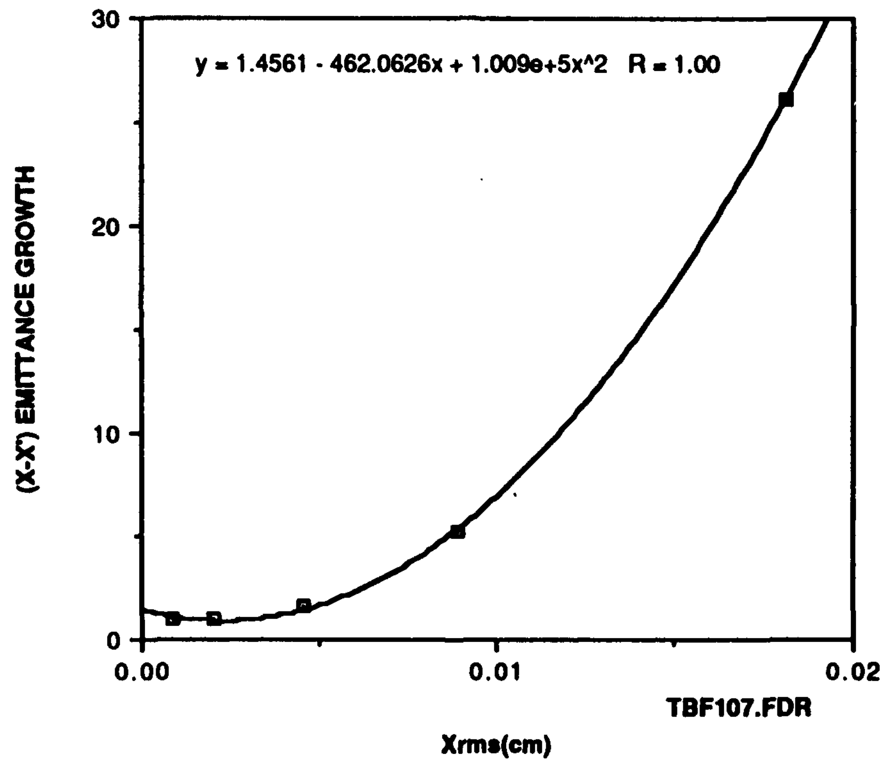
THE FIGURE SHOWS THE (X-X') EMITTANCE GROWTH AS A FUNCTION OF THE BEAM RMS HALF-WIDTH, Xrms, FOR THE RF DEFLECTOR. THE INPUT BEAM IS A PENCIL BEAM WITH VERY SMALL EMITTANCE AS SHOWN BELOW.

	TBF INPUT BEAM	PENCIL BEAM
ε_x (π cm•mrad)	0.1461	0.0001
ε_y (π cm•mrad)	0.1511	0.0001
ε_z (π deg•MeV)	0.0817	0.000001

A BASIC SCALING ARGUMENT SHOWS THAT FOR FUNNELING IN THE (X-Z) PLANE, THE (X-X') EMITTANCE GROWTH SCALES AS THE SQUARE OF THE BEAM RADIUS, Xrms. THE CURVE FIT IN THE FIGURE CONFIRMS THIS SCALING LAW.

RF DEFLECTOR EMITTANCE GROWTH

RF DEFLECTOR EMITTANCE GROWTH vs. Xrms



McDonnell Douglas Missile Systems Company

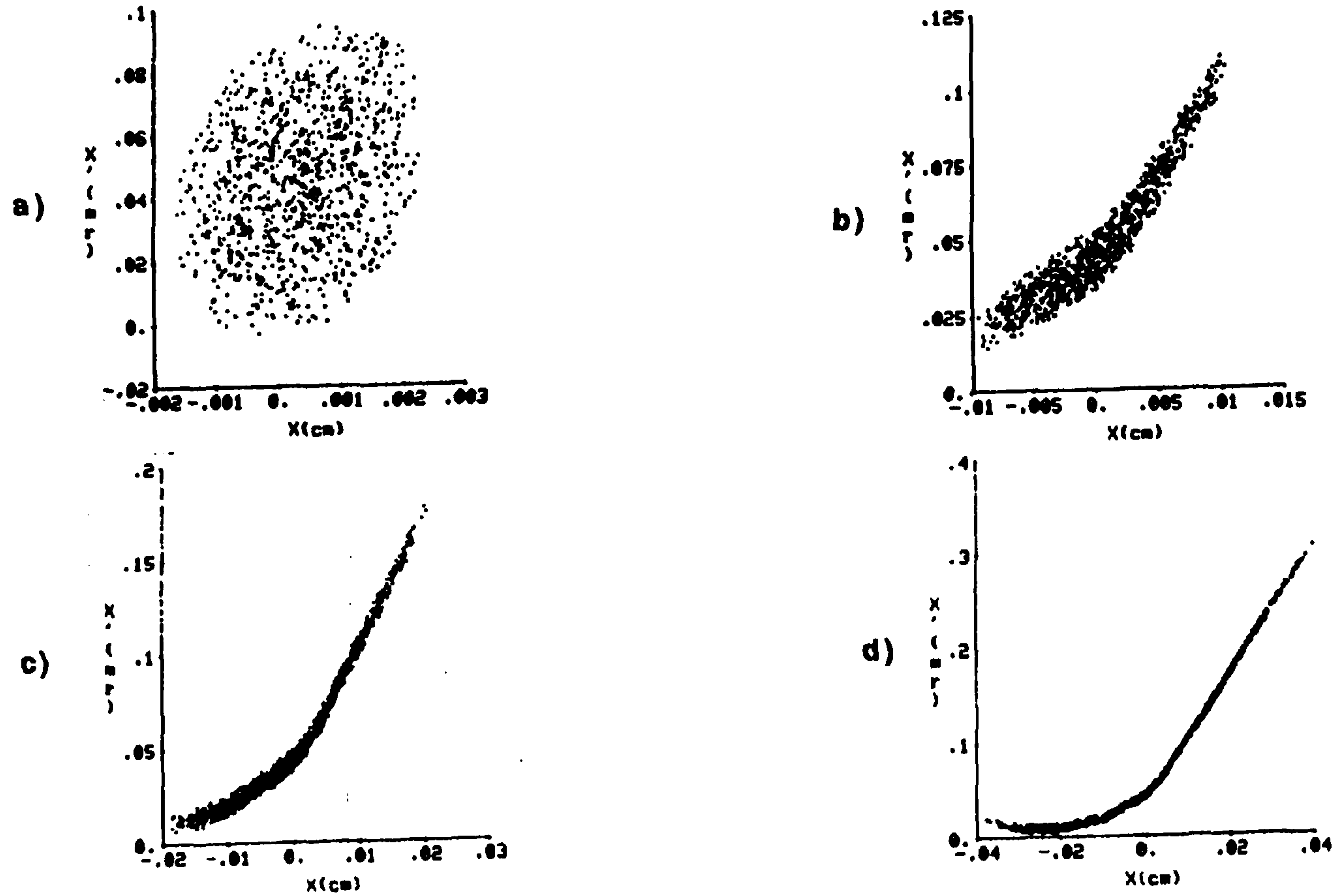
RF DEFLECTOR EMITTANCE GROWTH (X-X')SCATTER PLOTS

THE FIGURE SHOWS (X-X') SCATTER PLOTS FOR VARIOUS PENCIL BEAMS PASSING THROUGH THE RF DEFLECTOR. EACH BEAM WAS GENERATED USING CONSTANT VALUES OF α_x (=0) AND ε_x (=0.0001 π cm•mrad). VARIOUS VALUES OF β_x WERE USED TO GENERATE BEAMS FOR USE WITH THE RF DEFLECTOR AS SHOWN BELOW:

	β_x (cm/mrad)	X_{RMS} (cm)
a)	0.04	0.0008803
b)	1	0.004570
c)	4	0.008926
d)	16	0.01808

AS β_x INCREASES, THE RMS BEAM RADIUS INCREASES AND THE RF PRODUCES INCREASING AMOUNTS OF CORRELATION BETWEEN X AND X' WHILE SIMULTANEOUSLY INTRODUCING NON-LINEAR EFFECTS. THESE TWO EFFECTS ARE CAUSED BY THE FINITE WIDTH OF THE INPUT BEAM AND PRODUCE THE OBSERVED EMITTANCE GROWTH IN THE RF DEFLECTOR.

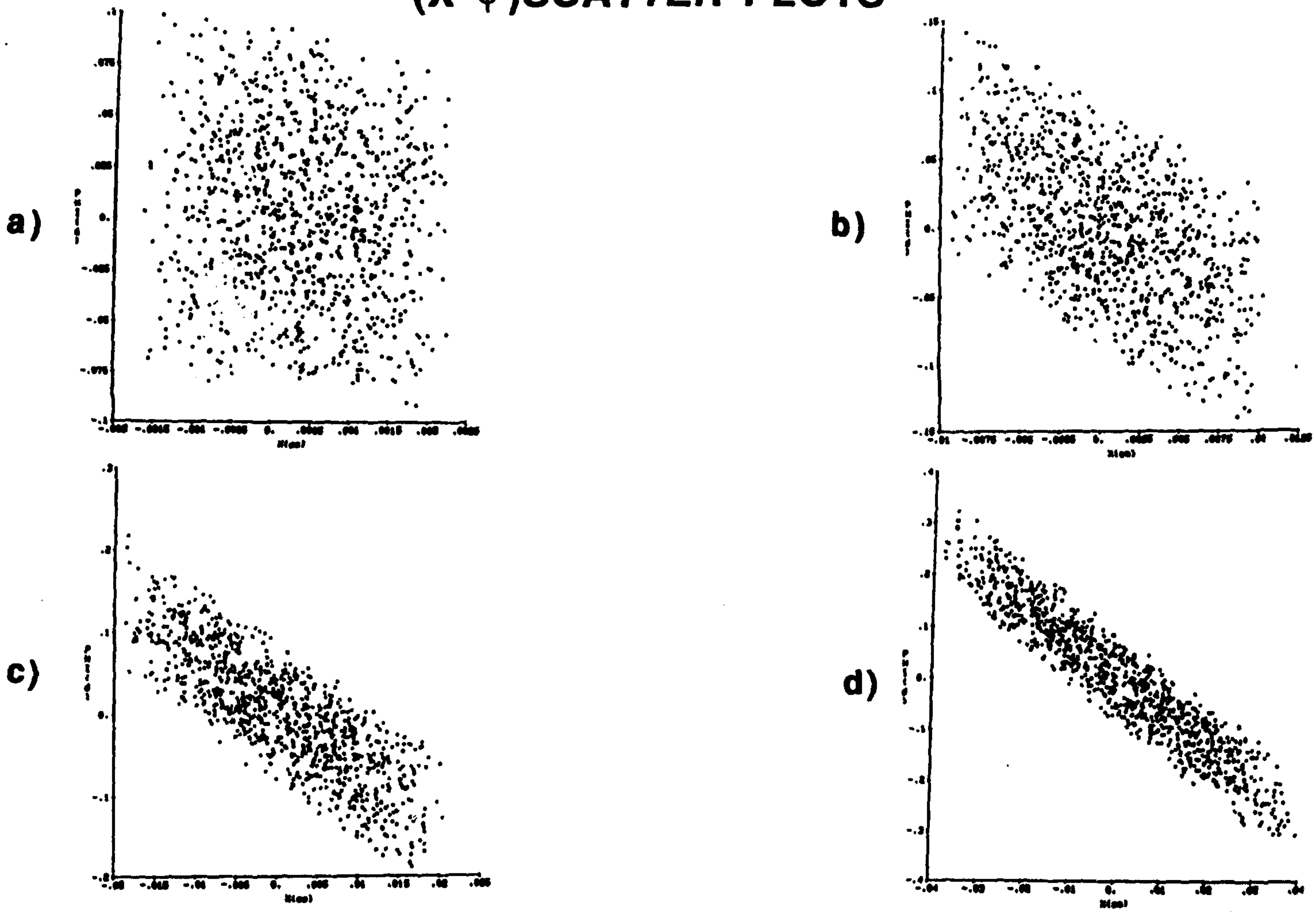
RF DEFLECTOR EMITTANCE GROWTH (X-X')SCATTER PLOTS



RF DEFLECTOR EMITTANCE GROWTH (X-ϕ)SCATTER PLOTS

THE FIGURE SHOWS THE CORRELATION BETWEEN X_{rms} AND ϕ FOR VARIOUS VALUES OF RMS BEAM X-RADIUS. AS THE RADIUS INCREASES, THE RF DEFLECTOR FIELDS PRODUCE INCREASING AMOUNTS OF CORRELATION BETWEEN THE TWO VARIABLES. THIS LARGE CORRELATION BETWEEN X_{rms} AND ϕ IS ACCOMPANIED BY INCREASING AMOUNTS OF (X-X') EMITTANCE GROWTH IN THE RF DEFLECTOR.

RF DEFLECTOR EMITTANCE GROWTH
(X-ϕ)SCATTER PLOTS

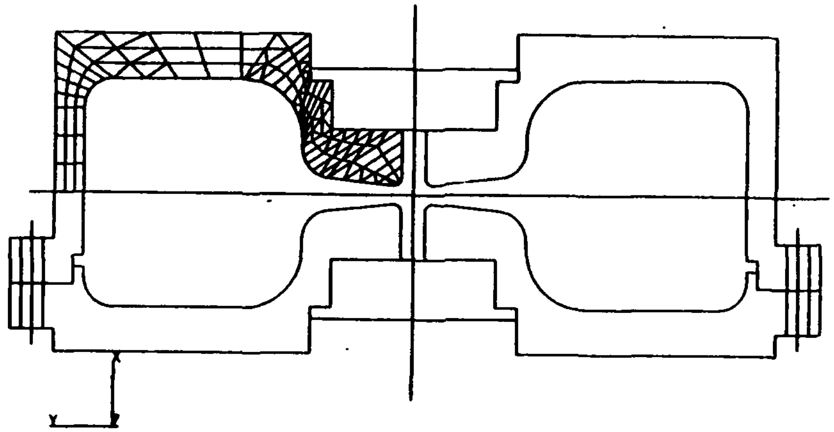


McDonnell Douglas Missile Systems Company

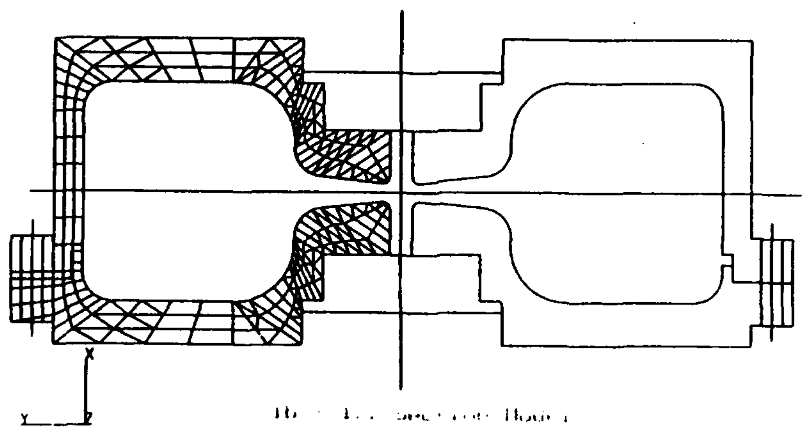
FINITE ELEMENT MODELS - G1 REBUNCHER

THE FIGURE SHOWS THE TWO FINITE ELEMENT MODELS USED IN THE THERMO-MECHANICAL ANALYSIS OF THE SINGLE HOLE REBUNCHER, G1. INITIAL ANALYSIS WAS DONE WITH THE 1/4 SECTION 2-D MEMBRANE SLICE MODEL. ADDITIONAL ANALYSES WERE CONDUCTED USING THE 1/2 SECTION SLICE MODEL TO VERIFY TRENDS SEEN WITH THE 1/4 SECTION MODEL. THE CROSS SECTION GEOMETRY WAS DEFINED INITIALLY USING THE 'UNI-GRAPHICS' CAD SYSTEM. THEN THE MESHING OF THE FINITE ELEMENT MODELS WAS DONE USING WEIGHTING CORRESPONDING ROUGHLY TO THE GIVEN RF HEAT LOAD DISTRIBUTION FROM SUPERFISH.

FINITE ELEMENT MODELS - G1 REBUNCHER



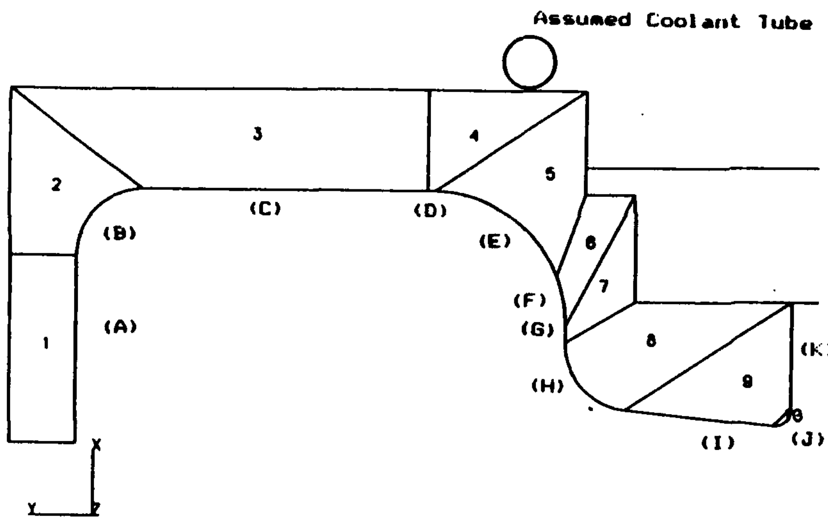
1a - 1/4 Section Model



THERMAL LOADING - G1 REBUNCHER

THE FIGURE SHOWS THE RF HEAT LOAD DISTRIBUTION ON REBUNCHER G1 FROM SUPERFISH. THE STEADY STATE HEAT LOADS WERE OBTAINED USING A DUTY FACTOR OF 0.125%. ASSUMING RADIAL AND AXIAL SYMMETRY ALLOWS THE THERMAL ANALYSIS TO BE DONE WITH THE 1/4 SECTION MODEL. THE THERMAL ANALYSES ASSUMED THE PLACEMENT OF UPPER AND LOWER COOLANT TUBES AS SHOWN IN THE FIGURE TO ACHIEVE MAXIMUM COOLING NEAR THE REBUNCHER NOSE REGION. THERMAL EXPANSION EFFECTS ARE EXPECTED TO CHANGE THE CAVITY RESONANCE FREQUENCY BY CAUSING CHANGES IN CAPACITANCE DUE TO VARIATIONS IN THE GAP DIMENSIONS IN THE NOSE REGION.

THERMAL LOADING - G1 REBUNCHER



SEGMENT	POWER*
A	1220 W
B	706 W
C	2403 W
D	72.7 W
E	1783 W
F	620 W
G	190 W
H	823 W
I	295 W
J	0.61 W
K	.0023 W

* POWER DOES NOT INCLUDE DUTY FACTOR

TEMPERATURE DISTRIBUTIONS -G1 REBUNCHER

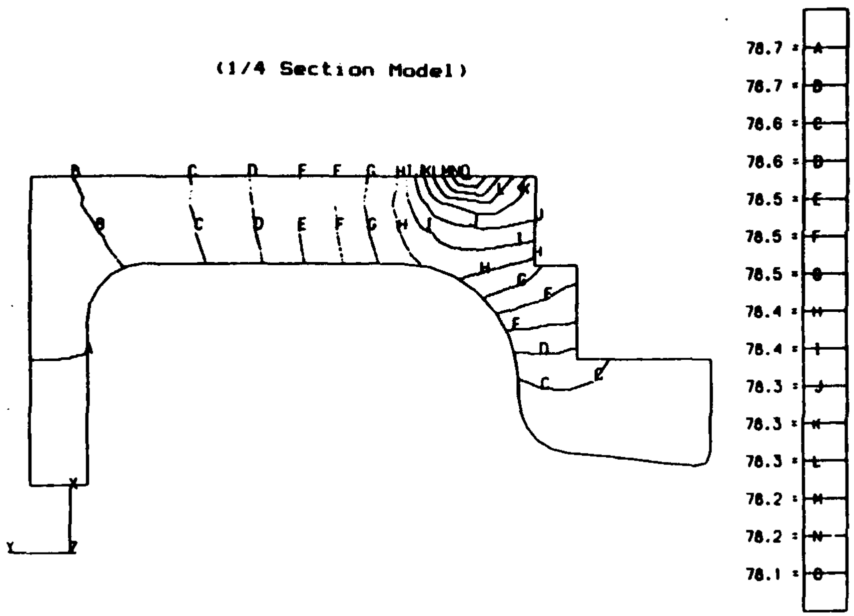
THE FIGURE SHOWS THE TEMPERATURE DISTRIBUTIONS CALCULATED USING THE 'PTHERMAL' ANALYSIS CODE FOR ALUMINUM AND STAINLESS STEEL SUBSTRATES. THE THIN COPPER COATING USED ON THE INTERIOR SURFACES WAS NEGLECTED IN THIS ANALYSIS. BOTH MATERIALS SHOW THE SAME QUALITATIVE TEMPERATURE DISTRIBUTIONS, THE DIFFERENCE BEING ONE OF MAGNITUDE. THE TEMPERATURE RISE FOR THE COPPER CAVITY IS ~1F WHILE STAINLESS STEEL SHOWS ~5.5F RISE.

TEMPERATURE DISTRIBUTIONS -G1 REBUNCHER

21SEP89
TBF021.FDR

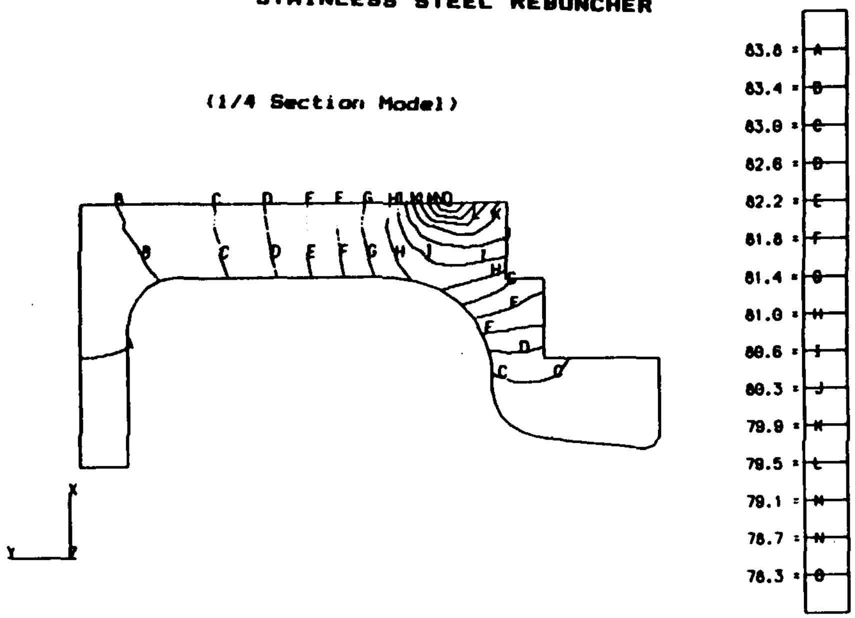
TEMPERATURE DISTRIBUTION
FOR ALUMINUM REBUNCHER

(1/4 Section Model)



- TEMPERATURE DISTRIBUTION FOR
STAINLESS STEEL REBUNCHER

(1/4 Section Model)



McDonnell Douglas Missile Systems Company

STRUCTURAL ANALYSIS BOUNDARY CONDITIONS

THE FIGURE SHOWS THE 1/4 SECTION MODEL WITH A SINGLE COOLING TUBE AND A FLEXIBLE OUTER WALL. THE BOUNDARY CONDITIONS ARE SHOWN IN THE RIGHT PART OF THE FIGURE. THE OUTER WALL IS CLAMPED AT THE MIDPLANE AND THE CENTER NOSE BOUNDARY IS CONSTRAINED TO MOVE ONLY VERTICALLY. UNDER THESE ASSUMPTIONS, THE CENTER NOSE SECTION DEFLECTION IS AS FOLLOWS:

ALUMINUM	8.374×10^{-5} in (UPWARD)
STAINLESS STEEL	1.919×10^{-4} in. (UPWARD)

THE ANALYSIS WAS REPEATED FOR THE ALUMINUM MODEL WITH THE ENTIRE OUTER WALL HELD RIGID AND PRODUCED THE FOLLOWING RESULTS:

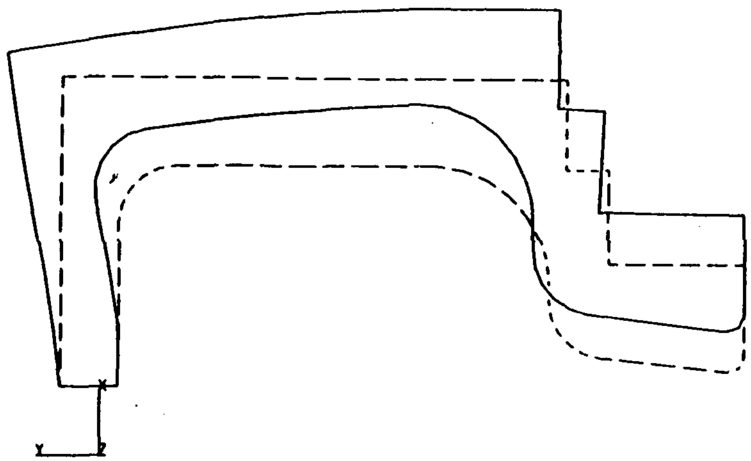
ALUMINUM	1.834×10^{-4} in. (DOWNWARD)

SELECTING ALUMINUM AS THE BASELINE SUBSTRATE, THE WORST CASE OCCURS UNDER THE ASSUMPTION THAT THE ENTIRE OUTER WALL IS RIGID. THIS FORCES BOTH THE UPPER AND THE LOWER CENTER NOSE SECTIONS TO CLOSE THE GAP BY

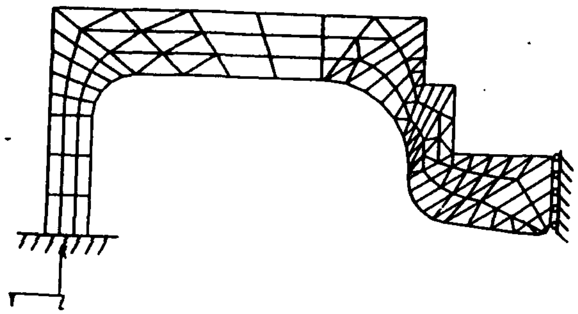
$$2 \times 1.834 \times 10^{-4} \text{in.} \sim 0.0004 \text{in.}$$

STRUCTURAL ANALYSIS BOUNDARY CONDITIONS

THERMAL INDUCED DEFLECTIONS DEPENDENT
ON ASSUMED BOUNDARY CONDITIONS



RBUNCHER THERMAL DEFLECTION ANALYSIS BY F.WILLIAMS
ASSUMES MATERIAL TO BE 6061 ALUMINUM
TEMPERATURE LOADING REFERENCE TEMPERATURE = 77 F



BOUNDARY CONDITIONS:

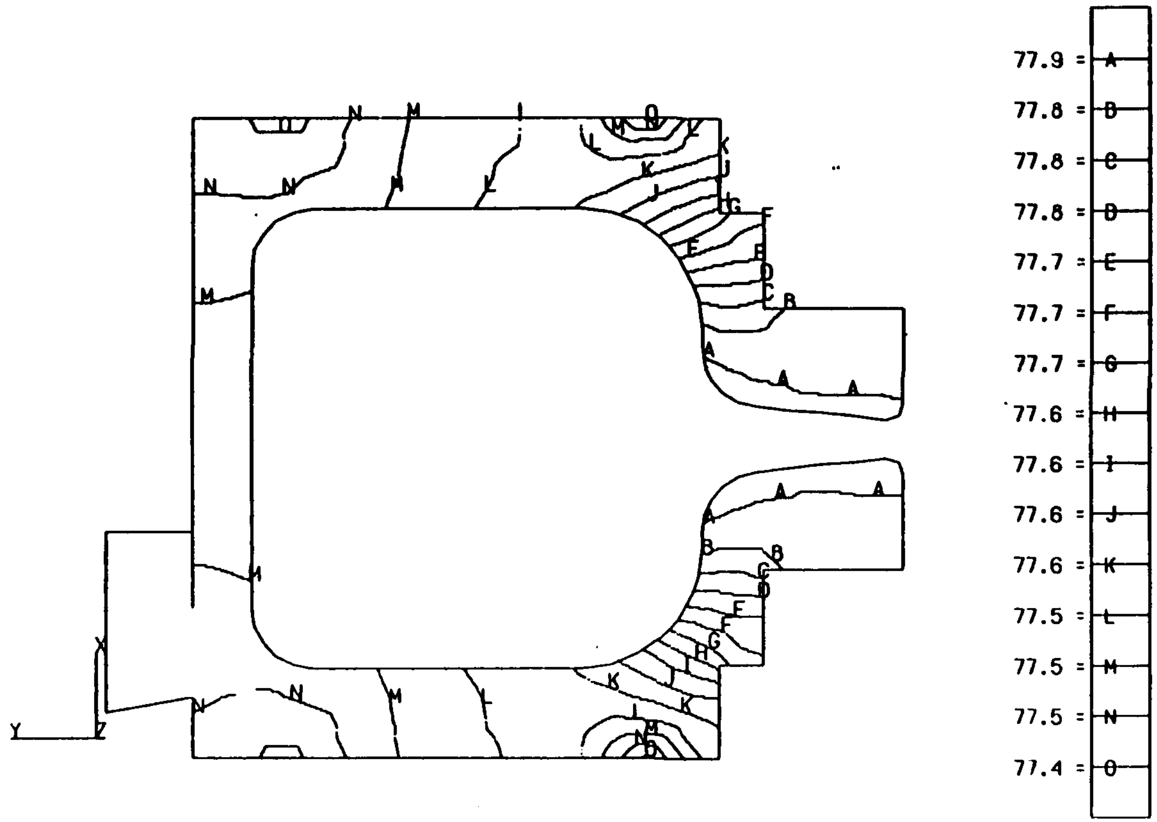
1. Fixed Bottom Radial Outer Wall
2. Constrained Horizontal Motion Inner Wall on Nose Section

BASELINE COOLING DESIGN - G1 REBUNCHER

A TOTAL OF FOUR COOLING TRACES ARE PROVIDED BY THE BASELINE G1 REBUNCHER DESIGN. TWO ARE LOCATED NEAR THE CAVITY NOSE PIECES AND TWO ARE LOCATED NEAR THE OUTER DIAMETER OF THE CAVITY. THE EXPECTED STEADY-STATE TEMPERATURE RISE IS ~0.5F.

21SEP89
TBF025.FDR

BASELINE COOLING DESIGN - G1 REBUNCHER



THERMAL DETUNING EFFECTS - G1 REBUNCHER

THE FIGURE SHOWS SUPERFISH RESULTS FOR THE G1 REBUNCHER. THE CAVITY NOSE SECTION CORRESPONDS TO SEGMENTS 11, 12 AND 13. SUPERFISH CALCULATES THE RESONANT FREQUENCY SHIFT FOR EACH SEGMENT PER mm OF AXIAL AND RADIAL MOVEMENT. THE CAVITY DETUNING IS DETERMINED MAINLY BY THE AXIAL MOTION (delz) OF SEGMENTS 11, 12 AND 13 AND AMOUNTS TO 25.884 MHz PER MILLIMETER CHANGE. ACCORDING TO THE THERMO-MECHANICAL ANALYSIS, EACH NOSE SECTION IS EXPECTED TO MOVE ABOUT 0.0002in. THE EXPECTED CHANGE IN RESONANT FREQUENCY IS ABOUT 131.5 kHz (i.e. A 0.031% CHANGE BASED ON A 425 MHz DESIGN FREQUENCY).

THERMAL DETUNING EFFECTS - G1 REBUNCHER

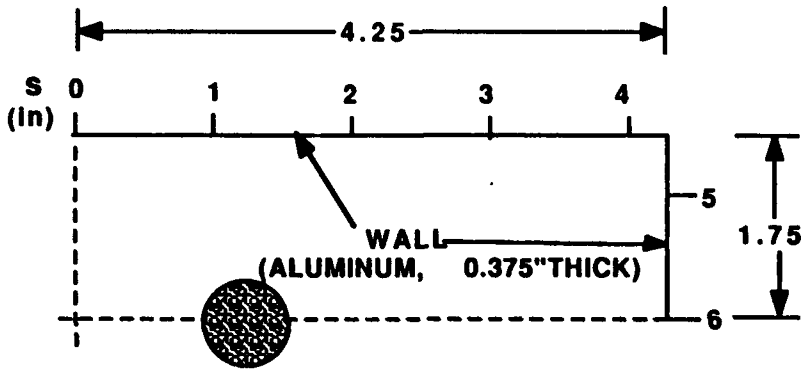
iseg	zbeg (cm)	rbeg (cm)	zend (cm)	rend (cm)	emax (mv)	power (w)		d-freq (delz)	d-freq (delr)
4	0.0000E+00	1.4315E+01	3.5475E+00	1.4315E+01	3.0867E-03	8.7680E+01	wall	0.0000E+00	-1.2985E+00
5	3.5475E+00	1.4315E+01	4.8175E+00	1.3045E+01	3.0470E-02	5.0717E+01	wall	-4.8280E-01	-4.7242E-01
6	4.8175E+00	1.3045E+01	4.8175E+00	7.5000E+00	1.9139E-01	1.7274E+02	wall	-2.3801E+00	0.0000E+00
7	4.8175E+00	7.5000E+00	4.8175E+00	7.3575E+00	1.8176E-01	5.2204E+00	wall	-7.1194E-02	0.0000E+00
8	4.8175E+00	7.3575E+00	3.2229E+00	5.0000E+00	3.4261E-01	1.2823E+02	wall	-1.3488E+00	-9.4747E-01
9	3.2229E+00	5.0000E+00	2.2775E+00	4.8175E+00	6.1725E-01	4.4578E+01	wall	-9.8377E-02	-4.6862E-01
10	2.2775E+00	4.8175E+00	1.9614E+00	4.8175E+00	8.9920E-01	1.3497E+01	wall	0.0000E+00	-3.3239E-02
11	1.9614E+00	4.8175E+00	6.9830E-01	3.6803E+00	3.5511E+00	5.9198E+01	wall	6.1672E+00	3.8949E+00
12	6.9830E-01	3.6803E+00	4.0180E-01	8.5900E-01	6.1832E+00	2.1179E+01	wall	1.8334E+01	1.9268E+00
13	4.0180E-01	8.5900E-01	7.25[illegible]E-01	5.0000E-01	6.6161E+00	4.3713E-02	wall	1.3829E+00	5.1931E-01
14	7.2500E-01	5.0000E-01	2.3[illegible]E+00	5.0000E-01	7.4412E-01	1.5979E-04	wall	0.0000E+00	7.7885E-03

POWER DISTRIBUTION ON RF BOX

THE FIGURE SHOWS A 1/4 SECTION OF THE RF BOX DESIGN USED FOR THE RF DEFLECTOR AND THE TWO HOLE REBUNCHER. THE PLOT SHOWS THE RELATIVE POWER AS A FUNCTION OF PERIMETER POSITION ON THE WALL OF THE BOX. THESE RELATIVE VALUES ARE SCALED BY THE LINEAR POWER (W/In) VALUES TO COMPUTE THE POWER DENSITIY (W/In ^{2}) ON THE WALL.

21SEP89
TBF032.FDR

POWER DISTRIBUTION ON RF BOX

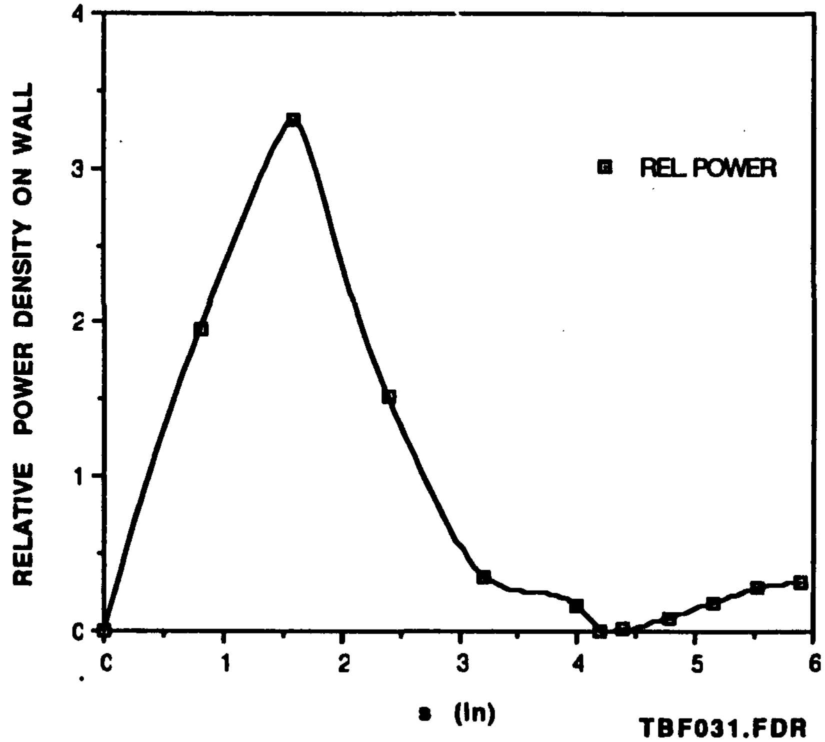


CENTER CONDUCTOR
COPPER
0.868" dia.
TWO PIECES ON 2.59" CENTERS

RF BOX DIMENSIONS: 8.5" x 3.5" x 16"

WALL POWER DISTRIBUTION

RF DEFLECTOR AND TWO HOLE REBUNCHER



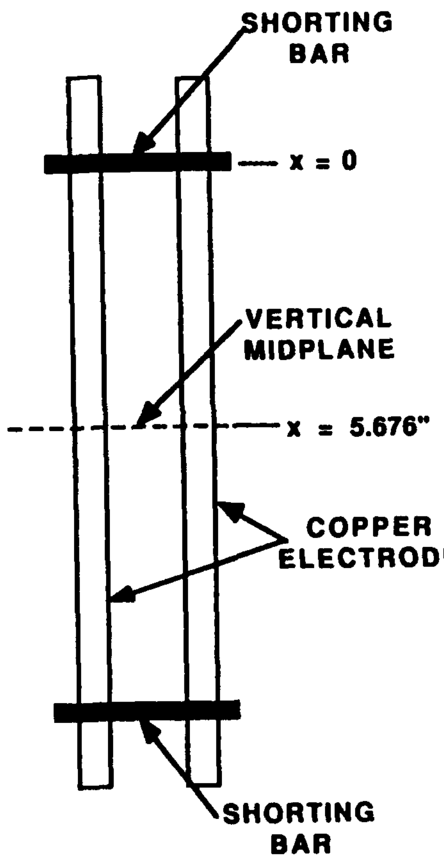
TBF031.FDR

McDonnell Douglas Missile Systems Company

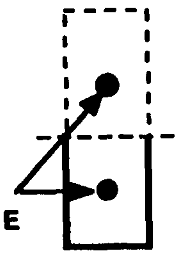
POWER DENSITY ON RF DEFLECTOR

THE FIGURE SHOWS THE POWER DENSITY (W/in) ALONG THE WALLS OF THE RF BOX AND ALONG THE COPPER ELECTRODES OF THE RF DEFLECTOR. THE SHORTING BAR IS LOCATED AT x=0 AND THE VERTICAL MIDPLANE CORRESPONDS TO x=5.676" IN THE TABULATED DATA. THE DATA IN THE "p-cond" COLUMN IS THE LINEAR POWER DENSITY ON ONE HALF OF ONE OF THE COPPER ELECTRODES IN W/in. SIMILARLY, "p-wall" IS THE LINEAR POWER DENSITY ON ONE HALF OF THE RF BOX AS SHOWN IN THE TOP VIEW. THE RF DUTY FACTOR (= 0.125%) HAS TO BE INCLUDED TO OBTAIN THE STEADY STATE POWER DENSITIES.

POWER DENSITY ON RF DEFLECTOR



SIDE VIEW



TOP VIEW

x in.	P-cond W/in.	P-wall W/in.
0.0	1337.3	166.9
0.2	1334.6	166.5
0.4	1326.4	165.5
0.6	1312.8	163.8
0.8	1294.0	161.5
1.0	1270.1	158.5
1.2	1241.2	154.9
1.4	1207.7	150.7
1.6	1169.8	146.0
1.8	1127.8	140.7
2.0	1082.0	135.0
2.2	1032.8	128.9
2.4	980.7	122.4
2.6	926.0	115.6
2.8	869.2	108.5
3.0	810.8	101.2
3.2	751.2	93.7
3.4	691.0	86.2
3.6	630.5	78.7
3.8	570.4	71.2
4.0	511.1	63.8
4.2	453.0	56.5
4.4	396.7	49.5
4.6	342.7	42.8
4.8	291.3	36.3
5.0	243.0	30.3
5.2	198.1	24.7
5.4	157.2	19.6
5.6	120.4	15.0
5.8	88.0	11.0
6.0	.	0.0

THERMAL ANALYSIS - RF DEFLECTOR BOX

THE FIGURE SHOWS THE TEMPERATURE DISTRIBUTION ON THE RF DEFLECTOR BOX. THE 'PTHERMAL' ANALYSIS CODE WAS USED AND THE FOLLOWING CONDITIONS IMPOSED ON THE DESIGN:

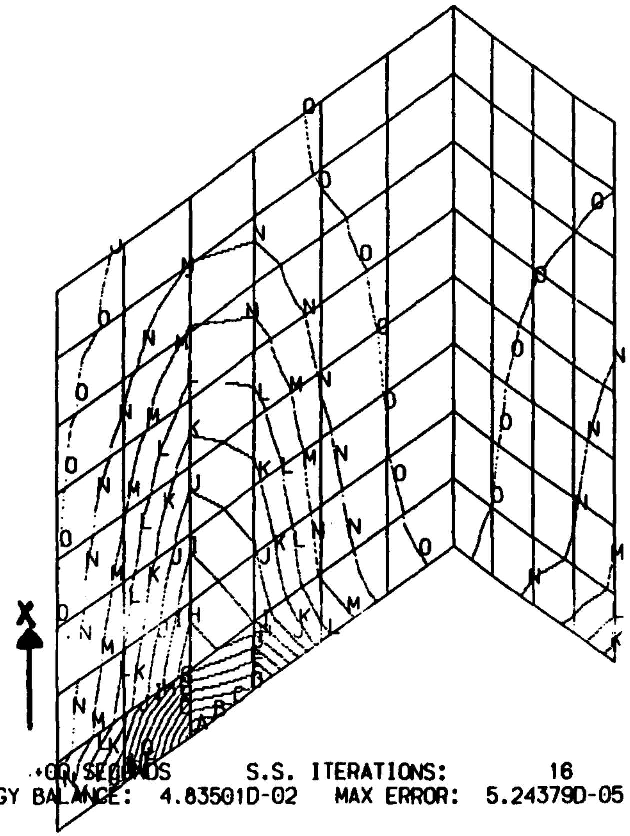
ALUMINUM WALL 0.375" THICK
RADIATIVE BOUNDARY CONDITIONS
SURFACE EMITTANCE = 1
NO CONVECTION COOLING
NO WATER COOLING

FOR THE HEAT LOADS SUPPLIED BY ACCSYS ANALYSIS, THE EXPECTED TEMPERATURE INCREASE IS NEGLIBIGLE (i.e. <0.2C^{o}).

REDUCING THE SURFACE EMITTANCE TO 0.2 (TYPICAL OF UNCOATED ALUMINUM) THE MAXIMUM TEMPERATURE INCREASES TO 25.5^{o}C.

THERMAL ANALYSIS - RF DEFLECTOR BOX

x in.	P-wall W/in.
0.0	166.9
0.2	166.5
0.4	165.5
0.6	163.8
0.8	161.5
1.0	158.5
1.2	154.9
1.4	150.7
1.6	146.0
1.8	140.7
2.0	135.0
2.2	128.9
2.4	122.4
2.6	115.6
2.8	108.5
3.0	101.2
3.2	93.7
3.4	86.2
3.6	78.7
3.8	71.2
4.0	63.8
4.2	56.5
4.4	49.5
4.6	42.8
4.8	36.3
5.0	30.3
5.2	24.7
5.4	19.6
5.6	15.0
5.8	11.0
6.0	4.0



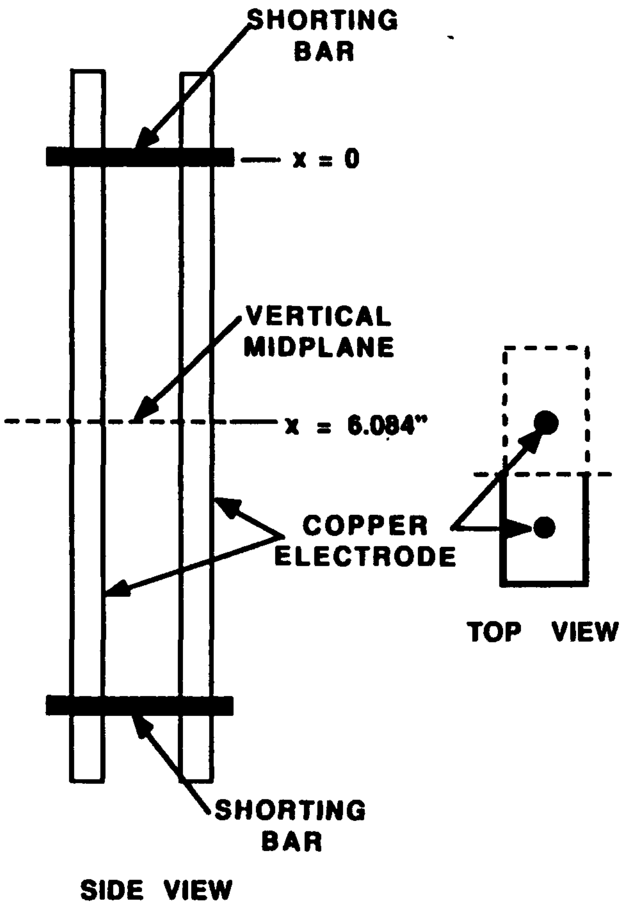
25.1	A
25.1	B
25.1	C
25.1	D
25.1	E
25.0	F
25.0	G
25.0	H
25.0	I
25.0	J
25.0	K
25.0	L
25.0	M
25.0	N
25.0	O

+00 SECONDS S.S. ITERATIONS: 16
TEMP SCALE: C ENERGY BALANCE: 4.83501D-02 MAX ERROR: 5.24379D-05
TITLE DATA

POWER DENSITY ON TWO HOLE REBUNCHER

THE FIGURE SHOWS THE POWER DENSITY (W/in) ALONG THE WALLS OF THE RF BOX AND ALONG THE COPPER ELECTRODES OF THE TWO HOLE REBUNCHER. THE SHORTING BAR IS LOCATED AT x=0 AND THE VERTICAL MIDPLANE CORRESPONDS TO x=5.676" IN THE TABULATED DATA. THE DATA IN THE "p-cond" COLUMN IS THE LINEAR POWER DENSITY ON ONE HALF OF ONE OF THE COPPER ELECTRODES IN W/in. SIMILARLY, "p-wall" IS THE LINEAR POWER DENSITY ON ONE HALF OF THE RF BOX AS SHOWN IN THE TOP VIEW. THE RF DUTY FACTOR (= 0.125%) HAS TO BE INCLUDED TO OBTAIN THE STEADY STATE POWER DENSITIES.

POWER DENSITY ON TWO HOLE REBUNCHER



x in.	P-cond W/in.	P-wall W/in.
0.0	1046.7	130.6
0.3	1041.9	130.0
0.6	1027.5	128.2
0.9	1003.9	125.3
1.2	971.5	121.2
1.5	930.8	116.2
1.8	882.7	110.1
2.1	827.9	103.3
2.4	767.6	95.8
2.7	702.7	87.7
3.0	634.6	79.2
3.3	564.4	70.4
3.6	493.5	61.6
3.9	423.1	52.8
4.2	354.6	44.2
4.5	289.1	36.1
4.8	228.0	28.4
5.1	172.3	21.5
5.4	123.0	15.3
5.7	81.1	10.1
6.0	47.3	5.9
6.3	22.3	2.8

THERMAL ANALYSIS - RF DEFLECTOR

COPPER CONDUCTOR: 0.868" OD x 0.25"ID x ~7"L

INSTANTANEOUS POWER OVER HALF OF ONE CONDUCTER = 4603W

TIME AVERAGED POWER WITH 0.125% DUTY FACTOR = 5.75W

FOR COOLANT FLOW OF 0.025kg/s (0.4GPM), COOLANT $\Delta T = 0.06C^{\circ}$

CONDUCTOR BULK TEMPERATURE RISE (TIME AVERAGED) = $0.02C^{\circ}$

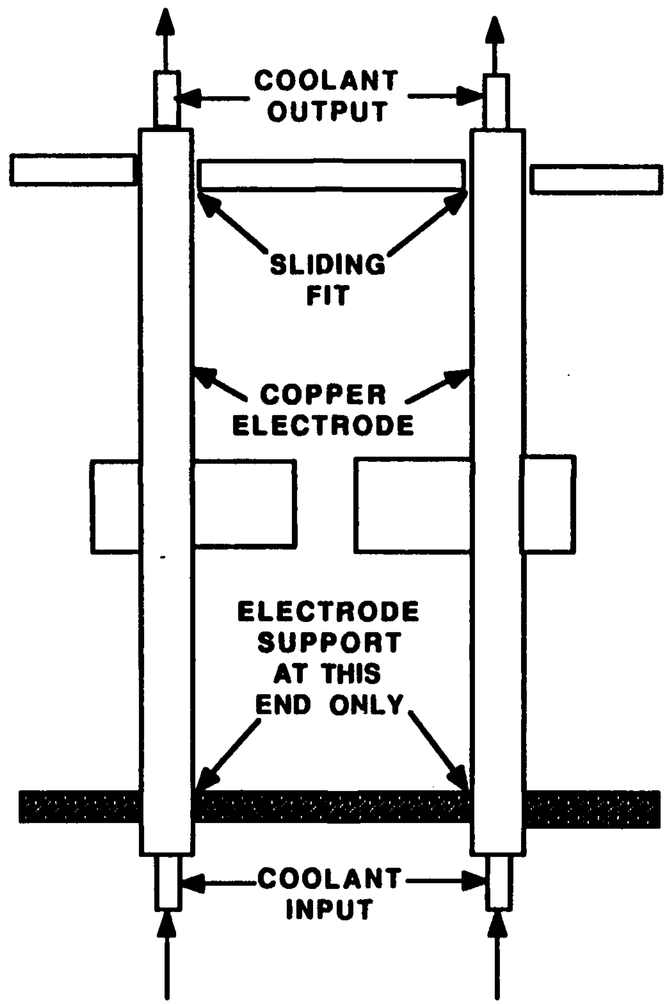
CONDUCTOR BULK TEMPERATURE RISE (MAXIMUM) = $0.08C^{\circ}$

FOR ASSUMED SURFACE HEATING, MAXIMUM SURFACE TEMPERATURE RISE DURING 100 microsecond PULSE = $0.25C^{\circ}$

CONCLUSION: COPPER CONDUCTOR WILL NOT EXPERIENCE SIGNIFICANT THERMAL EXCURSIONS

MAXIMUM INCREASE IN CONDUCTOR LENGTH IS ON THE ORDER OF TEN MICROINCHES

THERMAL ANALYSIS - RF DEFLECTOR

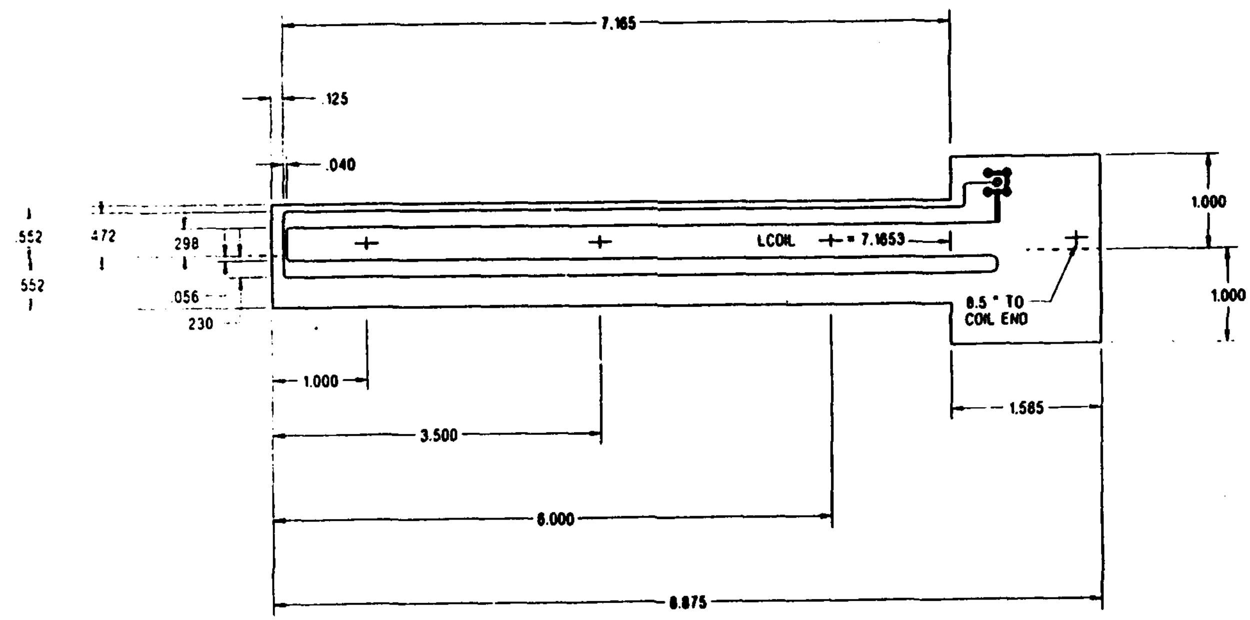


McDonnell Douglas Missile Systems Company

MAGNET QUALITY ASSURANCE

THE FIGURE SHOWS A COMPENSATED, SINGLE-TURN MAGNET PROBE ON A GLASS-EPOXY PRINTED CIRCUIT CARD. THE PROBE IS USED TO MEASURE THE STRENGTH OF THE DELIVERED MAGNETS FOR THE FUNNEL LATTICE. THE PROBE IS ATTACHED TO THE TAILSTOCK OF A PRECISION LATHE. THE MAGNET TO BE INSPECTED IS MOUNTED TO AN ALUMINUM COLLET WHICH IS CARRIED BY THE LATHE FACEPLATE. FOR THE FIELD GRADIENTS USED IN THE FUNNEL MAGNETS (~100T/m) AND AT 60 RPM, THE PROBE PRODUCES ABOUT 1 millivolt SIGNAL LEVELS. A DIGITAL OSCILLOSCOPE (TEK MODEL 11402) IS USED TO SIGNAL AVERAGE THE PROBE OUTPUT TO IMPROVE SIGNAL-TO-NOISE RATIO. HARMONIC ANALYSIS IS DONE ON THE OUTPUT FROM THE 11402 USING A COMPAQ COMPUTER AND SOFTWARE TO IMPLEMENT THE FAST FOURIER TRANSFORM ALGORITHM. MAGNET STRENGTH IS CALCULATED FROM THE AMPLITUDES OF THE HARMONICS AND THE KNOWN DIMENSIONS AND RPM OF THE MAGNET.

MAGNET QUALITY ASSURANCE



ALIGNMENT QUADRUPOLE HARDWARE

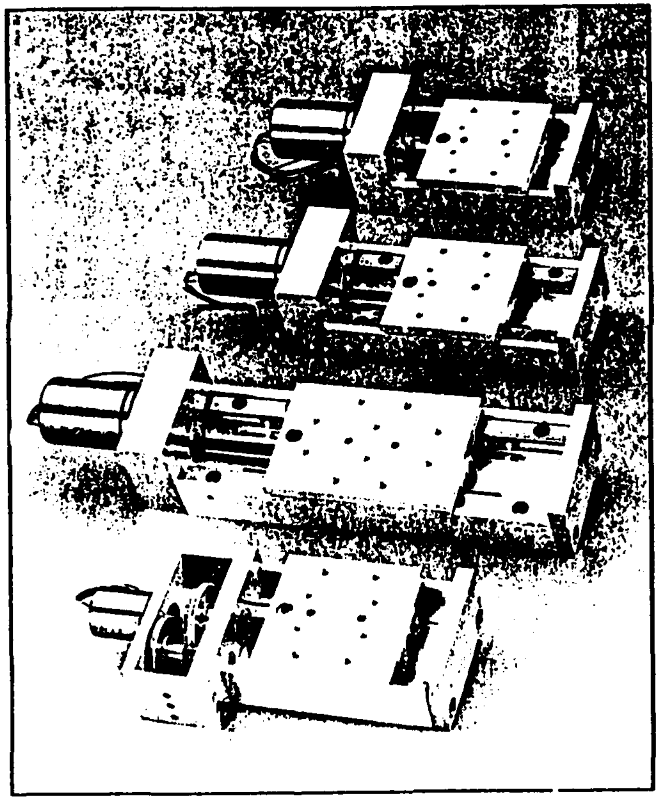
THE FIGURE SHOWS TWO TYPES OF MOTORIZED TRANSLATION STAGES THAT ARE SUITABLE FOR HIGH VACUUM USE. THE MISALIGNMENT ANALYSIS DONE BY KEN CRANDALL (AccSys, INC) SHOWS THAT QUADRUPOLES Q3 AND Q7 CAN BE USED TO COMPENSATE FOR MISALIGNMENTS OF THE TBF LATTICE QUADRUPOLES. TRANSLATIONAL MOVEMENTS OF +/-8 mm ARE SUFFICIENT TO HANDLE ANTICIPATED MISALIGNMENT EFFECTS. TWO-AXIS SLIDES SUCH AS THE ORIEL VERSION SHOWN IN THE FIGURE ARE NEEDED TO PROVIDE THE ADJUSTMENTS.

THE PRINCETON RESEARCH MOTORIZED SLIDE HAS EXCELLENT HIGH VACUUM CAPABILITY, BUT WILL REQUIRE THE ADDITION OF A POSITION SENSOR (e.g. A LVDT).

THE ORIEL MOUNT HAS AN INTEGRAL MOTORIZED MICROMETER DRIVE TOGETHER WITH A BUILT-IN POSITION ENCODER IN A SMALL PACKAGE. THIS UNIT IS RATED FOR 10^{-6} TORR SERVICE.

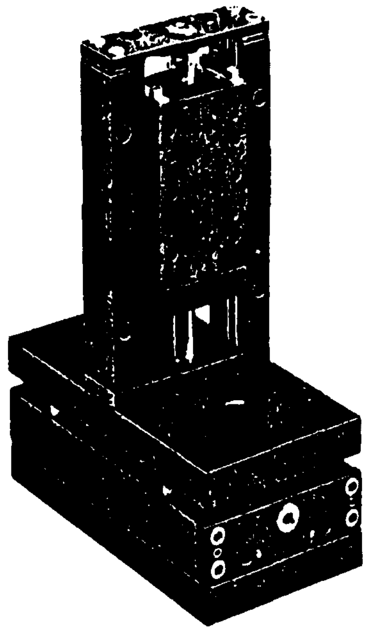
ALIGNMENT QUADRUPOLE HARDWARE

PRINCETON RESEARCH INSTRUMENTS, INC.
MODEL S1-23-8BP-40



ORIEL CORP.
MODEL 16728

Two Miniature Motorized Translators mounted in a Txz configuration with 19822 Adapters Plate.



ACCSYS ACTIVITIES

KEN CRANDALL

TBFE SENSITIVITY AND ERROR ANALYSIS

1. Sensitivity to beam properties at exit of RFQ (current, emittance, ellipse parameters, alignment, phase and energy jitter);
2. Phase and energy jitter in rebunchers;
3. Field errors in quadrupoles and dipoles;
4. Misalignments of quadrupoles and dipoles;
5. Corrective measures (energy adjustments and beam steering).

Tools Used in the Analysis: TRACE 3D, PARTRACE

21SEP89

TRACE 3D: First-order, interactive beam dynamics code, includes linear space-charge forces

PARTRACE: Combines input format and linac generation capabilities of PARMILA with beam dynamics of TRACE 3D.

Error Analysis Using PARTRACE:

Specify set of errors with tolerances;
Make many runs with random errors;
Save magnitude of undesirable effects;
Summarize results by probability distributions.

SENSITIVITY OF FUNNEL LINE TO INITIAL BEAM PROPERTIES

1. Insensitive to current
   (Easily transports 0, 10, 25 mA beams)

2. Insensitive to emittance
   (Easily transports twice the nominal emittance)

3. 20% mismatches easily acceptable
   40% mismatches probably acceptable

4. Tolerances on initial misalignments
   $x,y < 0.005''$; $x',y' < 2$ mrad
   $W < 1\%$ (20 keV)

5. Insensitive to phase and energy jitter
   (Easily accepts order of magnitude more jitter than is anticipated)

21SEP89

JITTER IN BEAM AT DEFLECTOR PRODUCED BY JITTER IN RF COMPONENTS

COMPONENT	1% AMPLITUDE JITTER	1^{o} PHASE JITTER
Rebuncher 1	Insignificant	1.14 keV
Rebuncher 2	Insignificant	2.63 keV
Deflector	$x' = 0.6$ mrad	Insignificant

FIELD ERRORS

Tolerance on quad gradients:
- 2–5% suitable for transporting beam
- 0.5% between quads in both lines

Tolerances on dipole fields
- 1% error causes 0.54 mm displacement in x at Q9, and 0.15 mm displacement at deflector

Dipole field errors can be compensated by displacing Q8 horizontally 0.294 mm for each 1% dipole field error

TOLERANCES ON MISALIGNMENT ERRORS

21SEP89

Quad displacements (x&y)	0.005"
Quad tilts (pitch & yaw)	2^{o} (insensitive)
Quad rotations	1^{o}
Dipole displacements (x&y)	0.040"
Dipole tilt (pitch & yaw)	1^{o}
Dipole rotation	0.25^{o}

(Can be compensated by displacing Q8 vertically by 0.23 mm per 1^{o} rotation)

CORRECTIVE MEASURES

Energy Corrections:

Adjust phase of R1 by 0.41° for each 1 keV error in energy

Beam Steering:

Displace either Q2 and Q6 or Q3 and Q7 to put beam on axis with zero angle at deflector. Probable displacements are less than 1 mm.

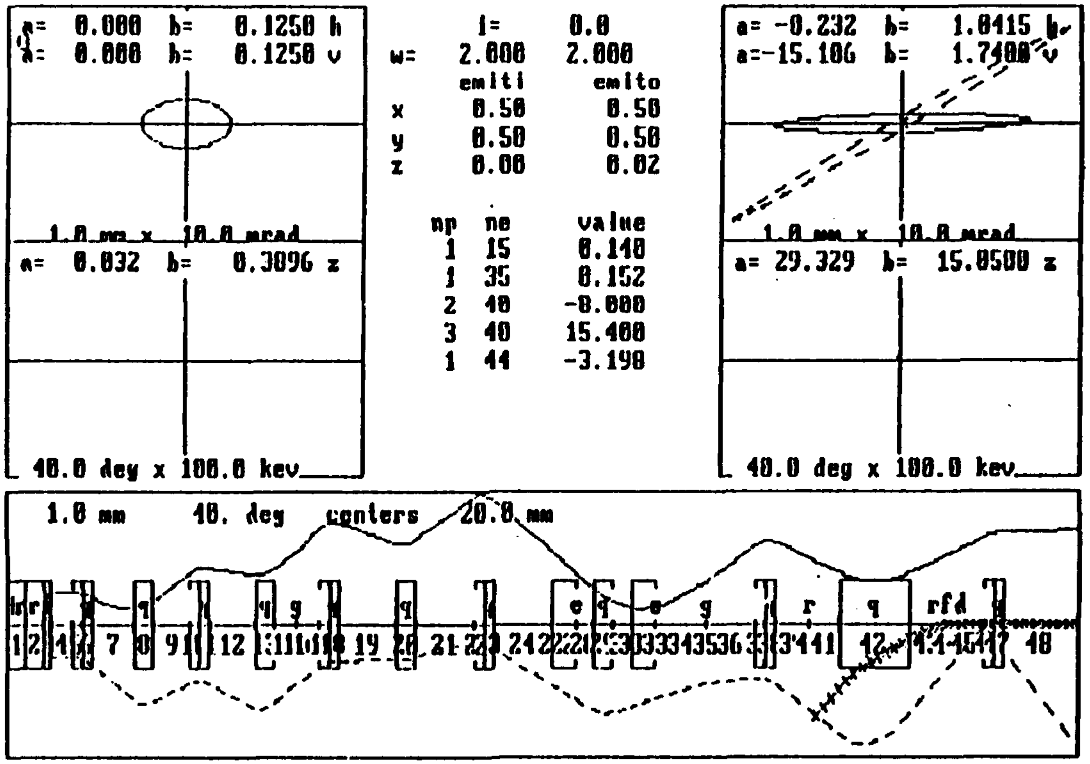


Fig. 12. Maximum displacements of beam center along funnel line (lower portion of display) when initial beam center lies inside of a 0.25 mm by 2.0 mrad ellipse in x-x' and y-y'. This shows the effect of misalignments of the funnel line with respect to the beam exiting the RFQ.

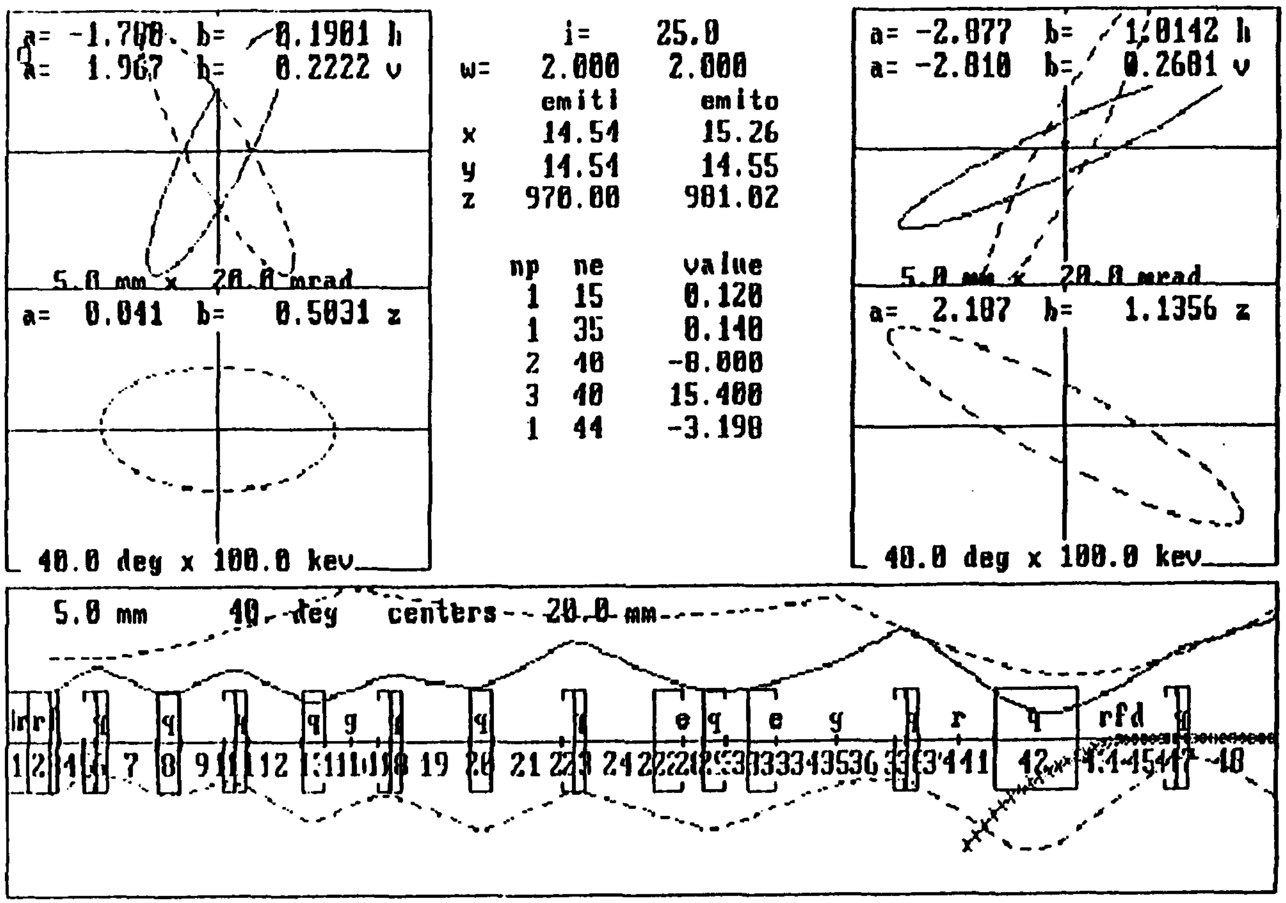


Fig. 10. Twenty-five mA beam having twice the nominal emittance in all three phase planes.

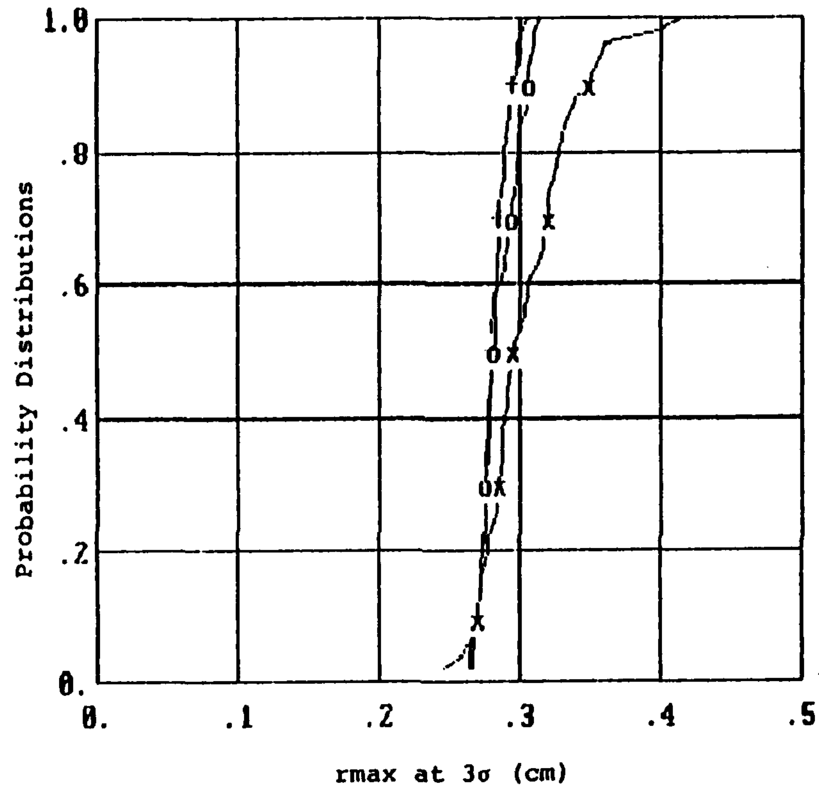


Fig. 19. Probability distributions for rmax (3σ) in the rebunchers and deflector produced from 50 PARTRACE runs in which the tolerance on the quad gradient errors were 1(+), 2(o), and 5% (x).

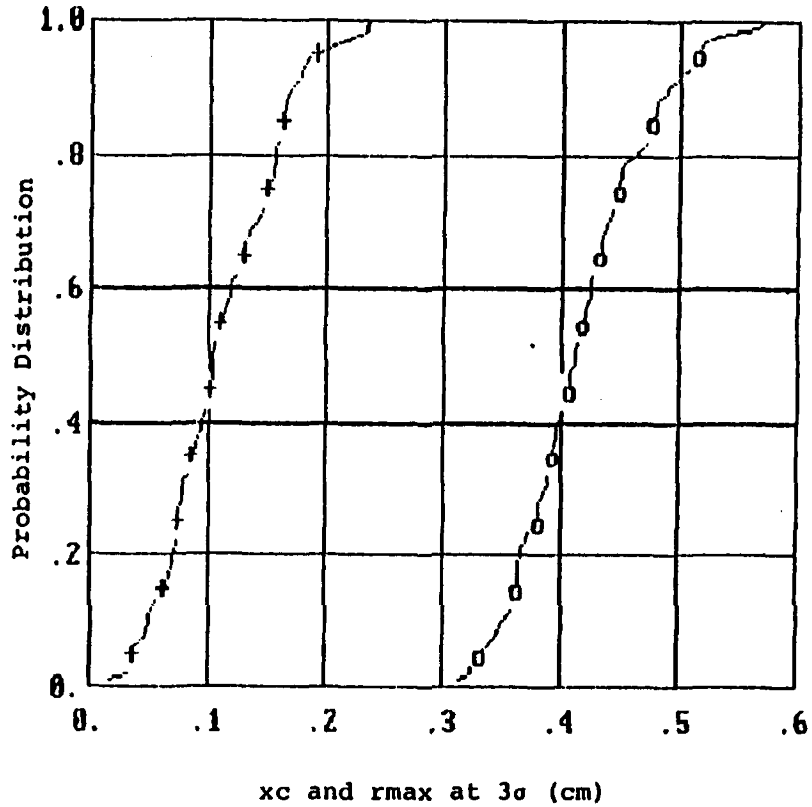


Fig. 26. Probability distributions for xc (+) and rmax (0) produced by 100 PARTRACE runs in which the following error tolerances were specified: 0.010" quad displacements; 2% quad gradient errors; 1° quad rotations; and 20% initial beam mismatch.

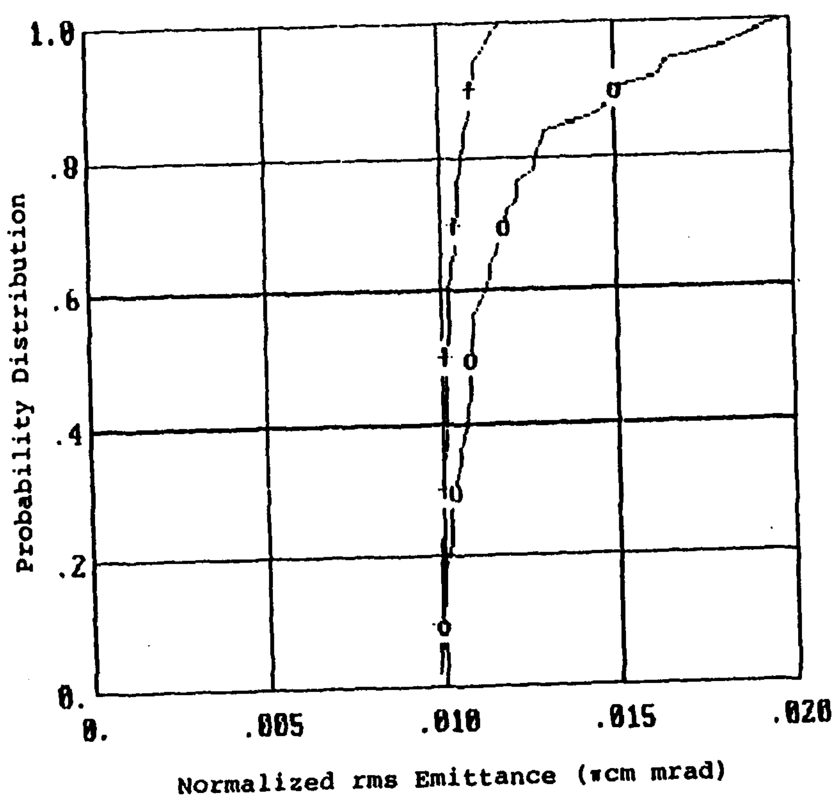


Fig. 25. Probability distributions for the transverse normalized rms emittance of the beam at the deflector produced by 50 PARTRACE runs in which the error tolerances on quad rotations were 1° (+) and 2° (0).

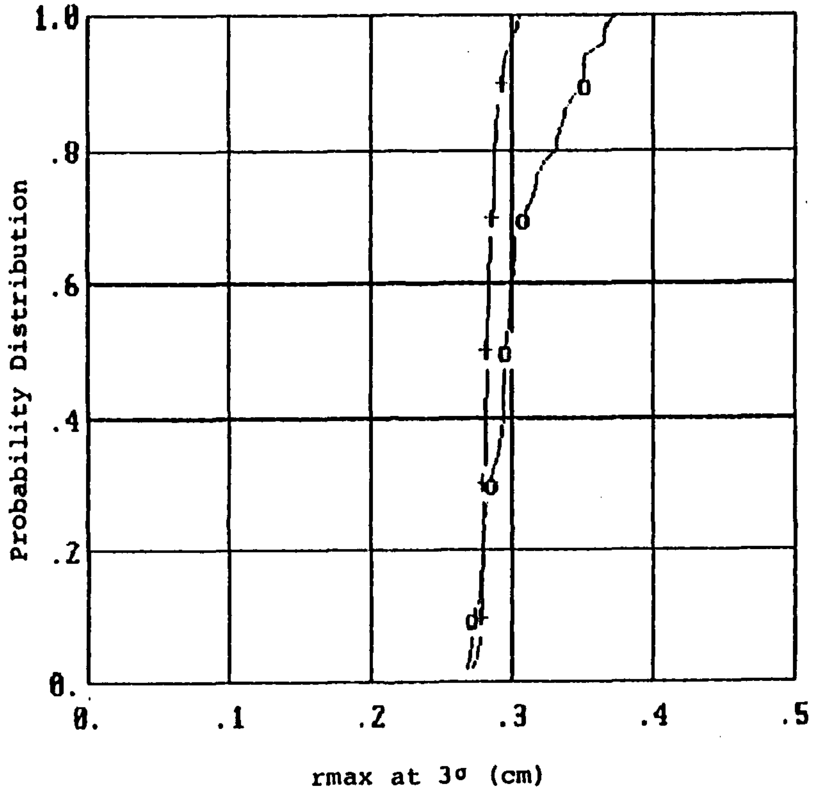


Fig. 24. Probability distributions for rmax produced by 50 PARTRACE runs in which the error tolerances on quad rotation were 1°and 2° (0).

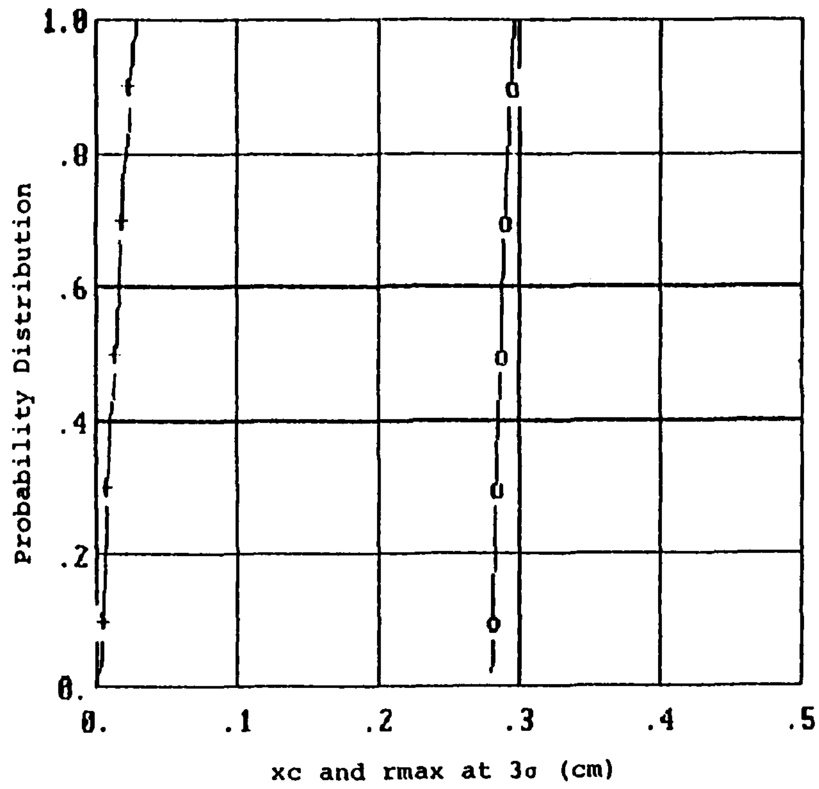


Fig. 23. Probability distributions for xc (+) and rmax (0) produced by 50 PARTRACE runs in which the error tolerance on quadrupole tilt (pitch and yaw) was 10°.

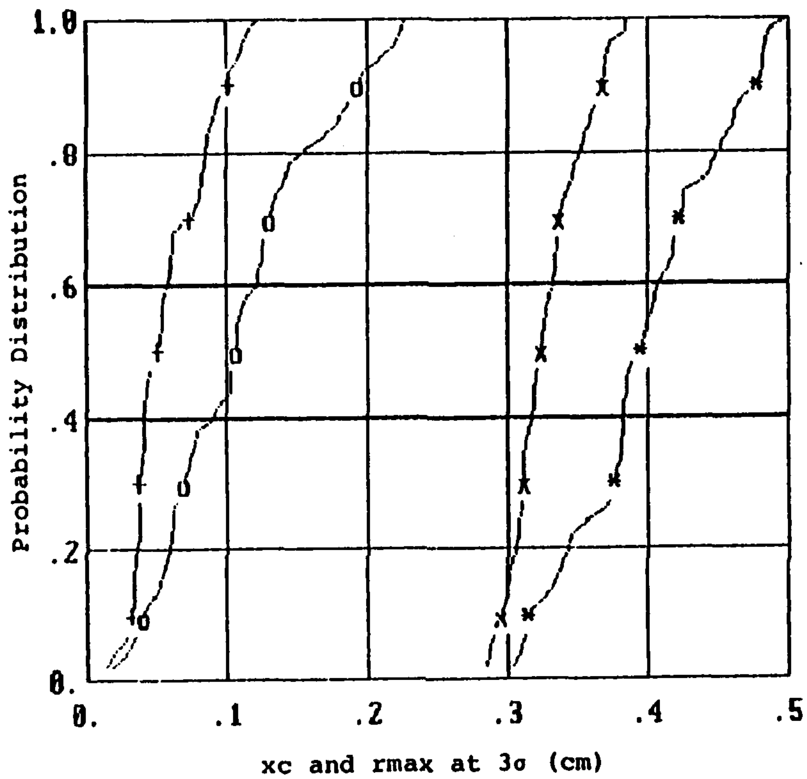


Fig. 22. Probability distributions for maximum displacement of beam center, xc, (+ and 0) and rmax (x and *) at the rebunchers and deflector produced by 50 PARTRACE runs in which the tolerances on quad displacements were 0.005" (+ and x) and 0.010" (0 and *).

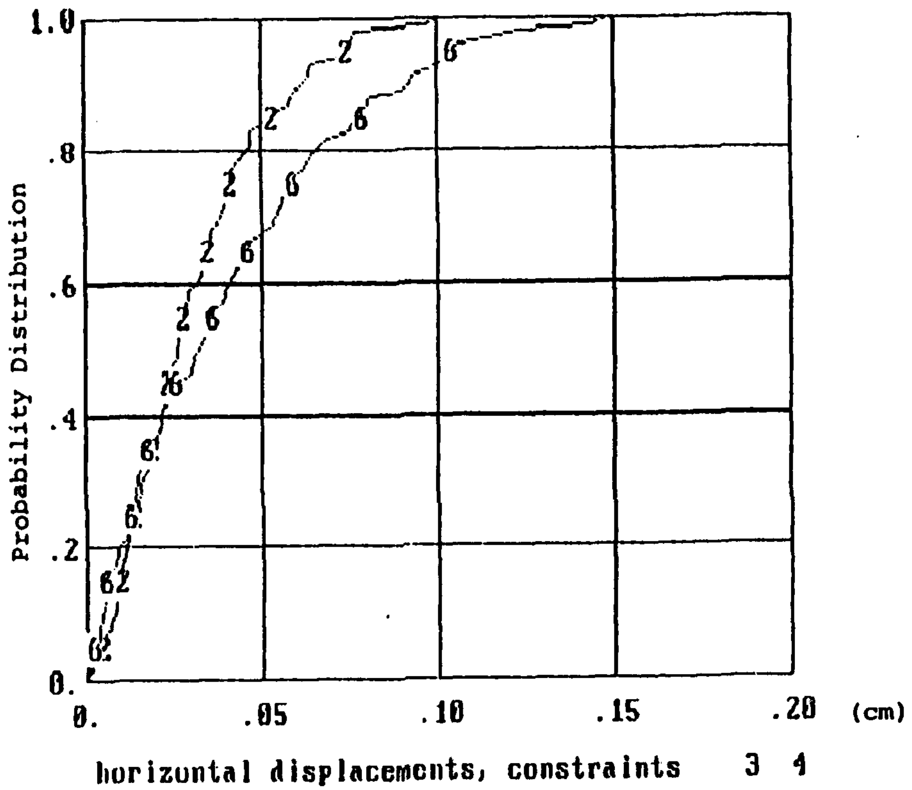


Fig. 43. Probability distribution for the horizontal displacements of Q2 and Q6 required to make xc and xc' zero at the deflector, compensating for random displacements within 0.010" of Q1 through Q10.

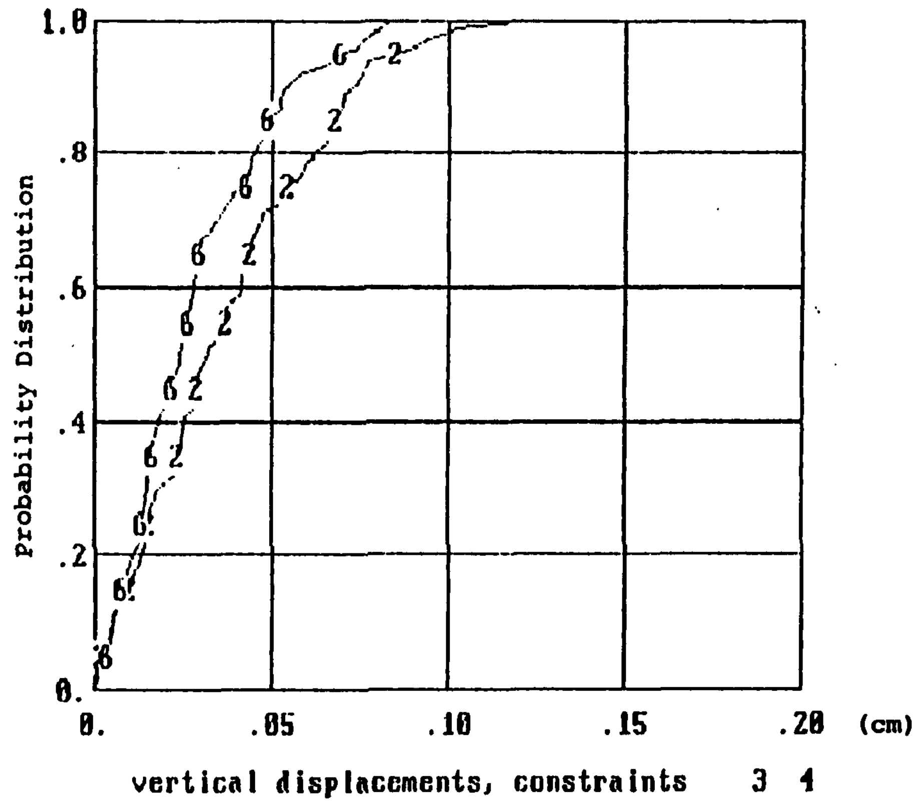


Fig. 44. Probability distribution for the vertical displacements of Q2 and Q6 required to make yc and yc' zero at the deflector, compensating for random displacements within 0.010" of Q1 through Q10.

RF COMPONENTS

JIM POTTER

MATERIAL IN THIS SECTION IS SEPARATELY BOUND

ENGINEERING DESIGN

JOE PAPA

THIS PAGE INTENTIONALLY LEFT BLANK

RESOLUTION OF OPEN ACTION ITEMS

MDAC SHOULD CONSIDER REDESIGNING (LENGTHENING) THEIR 32 INCH VACUUM SPOOL PIECE TO BE ADDED TO THE MAIN VACUUM VESSEL, SO IT CAN BE USED AS A TEMPORARY, STAND-ALONE VACUUM VESSEL FOR THE INITIAL RFQ CHARACTERIZATION AND ACCEPTANCE TESTING.

1. SPOOL PIECE NO LONGER EXISTS. UNAVAILABILITY OF MBF VACUUM VESSEL RESULTED IN THE DESIGN OF A NEW, DEDICATED TBF VACUUM VESSEL WITH NO SPOOL.

2. TBF VACUUM VESSEL TO BE DELIVERED TO MDMSC 15 FEB 90.

3. RFQ #1 TO BE DELIVERED TO MDMSC 03 APR 90.

THIS PAGE INTENTIONALLY LEFT BLANK

RESOLUTION OF OPEN ACTION ITEMS

DETERMINE WHETHER OR NOT A PROBLEM EXISTS WITH THE TRANSMISSION OF FLOOR VIBRATIONS. (INFORMAL)

1. THREE SEPARATE VIBRATIONAL SURVEYS HAVE BEEN PERFORMED IN BUILDING 101

   A. MAXIMUM FLOOR DISPLACEMENT OF LESS THAN .0001 INCH

   B. DISPLACEMENT IS INVERSELY MASS DEPENDANT. SURVEYS PERFORMED WITH LITTLE OR NO MASS.

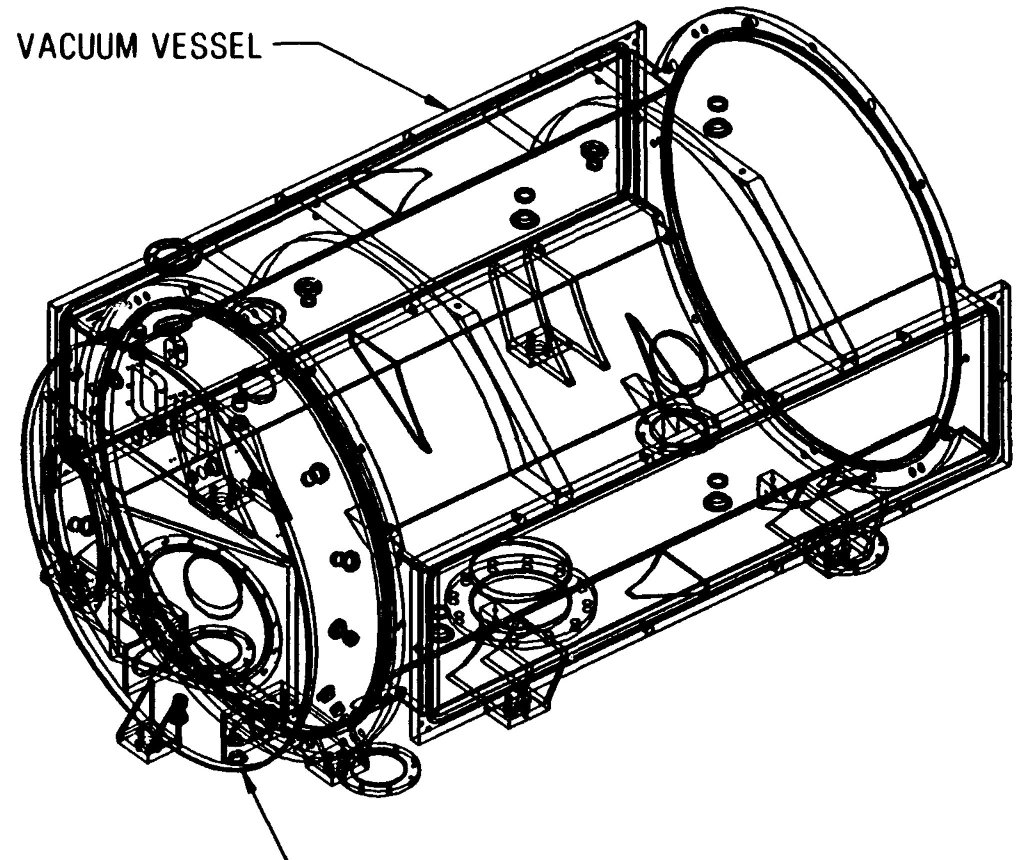
   C. FREQUENCY AT WHICH MAXIMUM DISPLACEMENTS WERE MEASURED WERE ALL LESS THAN 15 Hz

MDMSC UTILIZES UNIGRAPHICS II CAD SYSTEM

1. SAME METHOD AS USED ON LANL BEAR AND CDTL PROGRAMS WITH GREAT SUCCESS
2. THREE DIMENSIONAL (WIREFRAME) MODELING OF ALL HARDWARE
3. ALLOWS FOR THE IDENTIFICATION OF INTERFERENCES PRIOR TO HARDWARE FABRICATION
4. DRAWINGS NOT REQUIRED TO VALIDATE DESIGN, ONLY TO CONVEY DESIGN

21 SEPT 89

UNIGRAPHICS GENERATED WIREFRAME



McDonnell Douglas Missile Systems Company

MECHANICAL DESIGN STATUS

MDMSC SUPPLIED MECHANICAL HARDWARE FOR THE TBF EXPERIMENT IS DEFINED BY APPROXIMATELY 190 DRAWINGS. TO DATE 45% OF THOSE PARTS HAVE BEEN THREE DIMENSIONALLY MODELED (WIREFRAMED) AND HALF OF THOSE, DOCUMENTED WITH ENGINEERING DRAWINGS. CRITICAL PATH ITEMS (BEAM SCANNER AND VACUUM VESSEL) HAVE RECEIVED MOST OF THE DESIGN EFFORT. DESIGN AND DOCUMENTATION WILL CONTINUE IN A PRIORITIZED MANNER, WITH NEED DATES AND MANUFACTURING LEAD TIMES BEING THE DETERMINING FACTORS.

MECHANICAL DESIGN STATUS

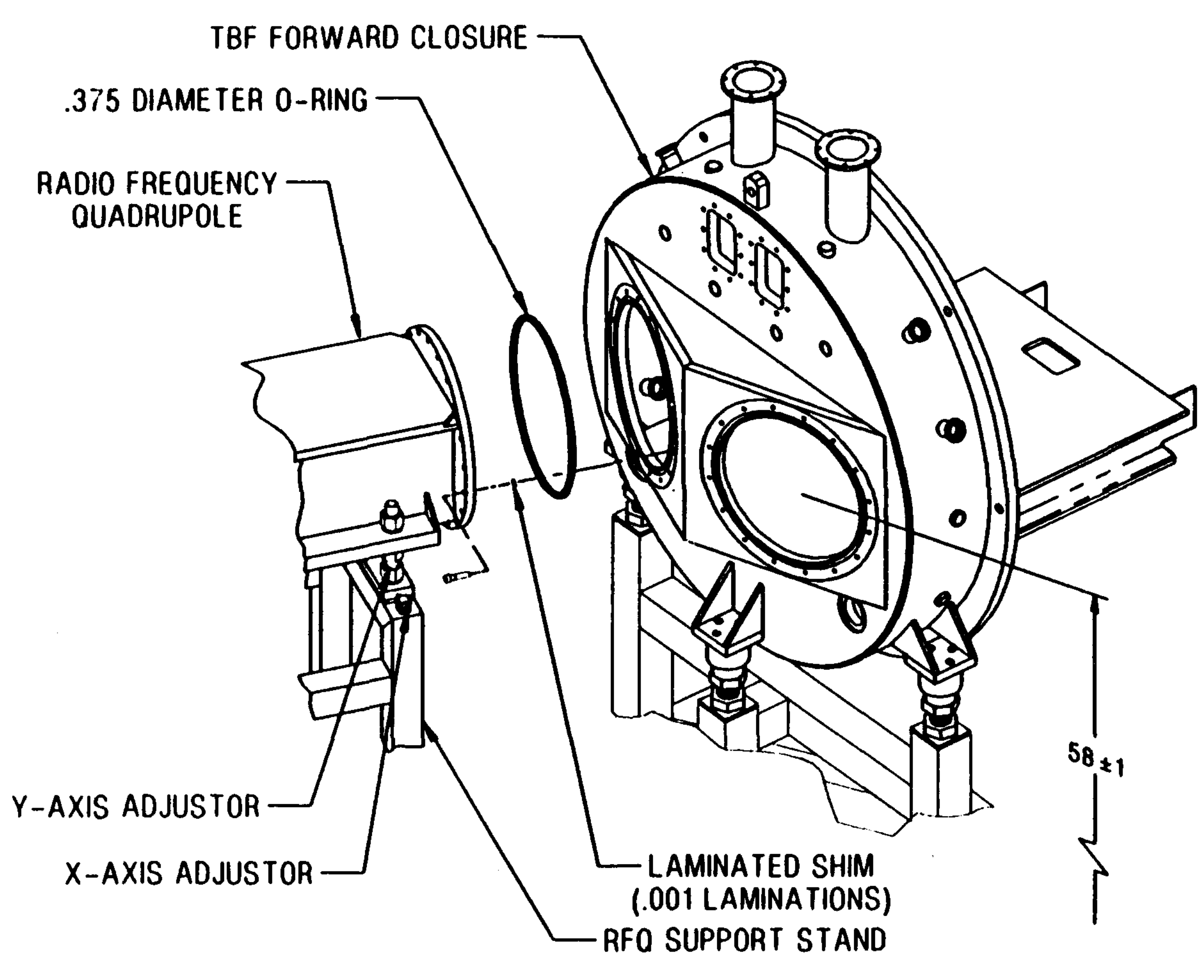
MAJOR SUBCOMPONENT	ESTIMATED NO. OF DRAWINGS	PERCENT DESIGN COMPLETE	PERCENT DRAWING COMPLETE	COMPLETION DATE (EST)
VACUUM VESSEL	14	80%	70%	31 DEC 89
BEAM SCANNER	100	40%	32%	31 DEC 89
SUPPORT STANDS	9	65%	0%	30 NOV 89
OPTICAL BENCH	10	75%	0%	31 DEC 89
MAGNET FRAMES	8	65%	0%	31 OCT 89
MAGNET/REBUNCHER SUPPORTS	25	30%	0%	31 DEC 89
RF FEEDTHRUS	11	60%	0%	30 NOV 89
TOTAL	187	45%	22%	31 DEC 89*

* DRAWINGS WILL BE COMPLETED IN A PRIORTY MANNER, DEPENDING ON NEED DATES, AND MANUFACTURING LEAD TIMES. NO EFFORT WILL BE MADE TO COMPLETE ONE MAJOR SUBCOMPONENT PRIOR TO INITIATING ANOTHER UNLESS IT IS DICTATED BY SCHEDULE.

FUNNEL - ACCELERATOR INTERFACE

THE FUNNEL TO ACCELERATOR PHYSICAL INTERFACE WAS AGREED TO AT ACCSYS ON 17 JULY 1989. SIXTEEN 3/8 INCH BOLTS, ON A 17.5 INCH DIAMETER, OFFSET 11.25° FROM THE HORIZONTAL WILL CONNECT EACH ACCELERATOR TO THE FUNNEL. A .375 INCH CROSS SECTIONAL DIAMETER O-RING WILL BE USED IN LIEU OF BELLOWS TO ACCOMODATE FOR UP TO ±.25° MISMATCH BETWEEN THE ALIGNED ACCELERATORS AND THE FORWARD CLOSURE.

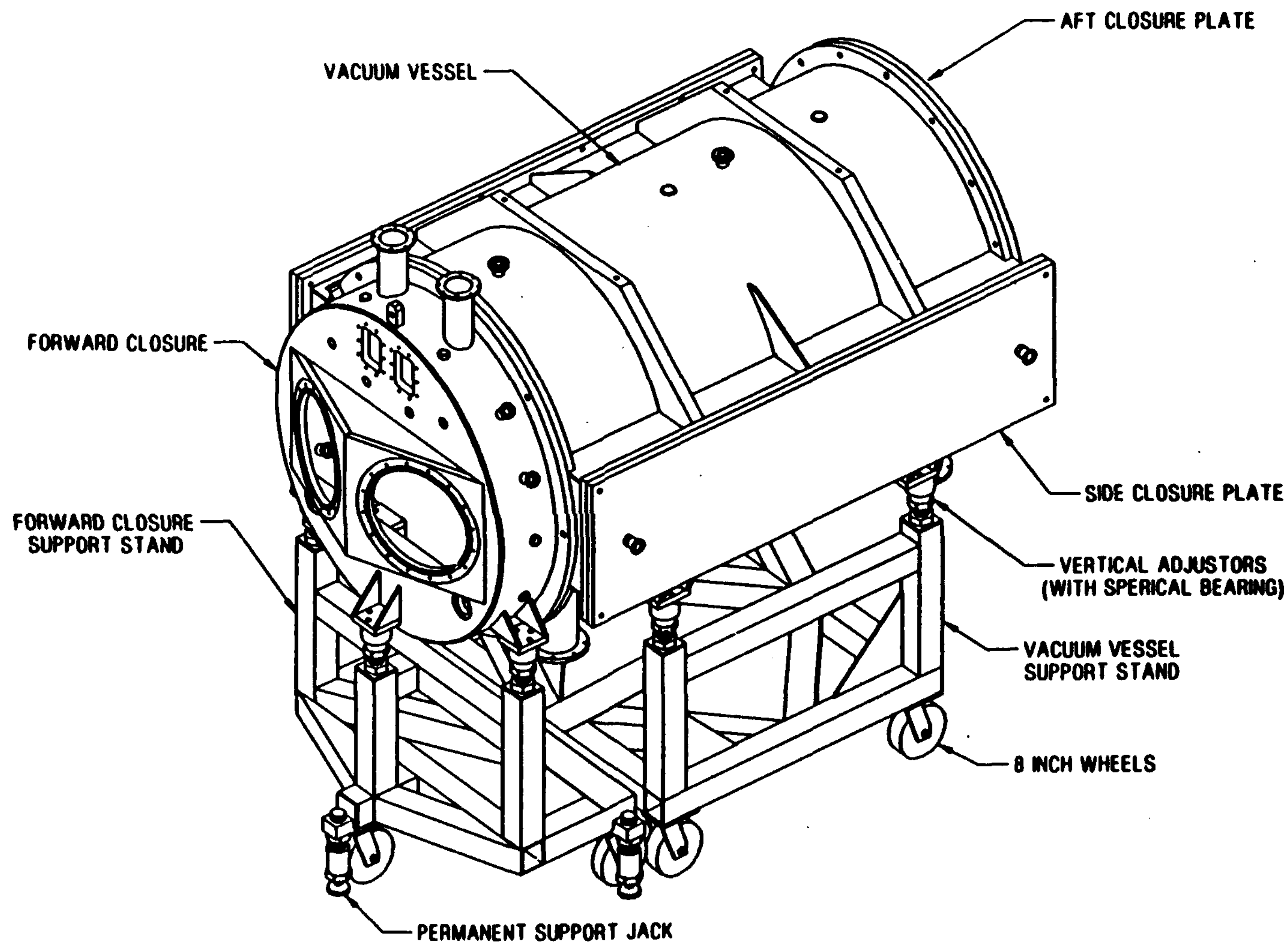
FUNNEL - ACCELERATOR INTERFACE



TBF EXPERIMENT ASSEMBLY

THE TIMELY ASSEMBLY AND ALIGNMENT OF THE TWO BEAM FUNNEL EXPERIMENT REQUIRES THE FUNNEL BE READILY ACCESSABLE. A ROLL-AWAY VACUUM CHAMBER PROVIDES THE NECESSARY ACCESSABILITY. THE FUNNEL, MOUNTED TO THE FORWARD CLOSURE, WILL BE PERMANENTLY POSITIONED ONCE ALIGNED WITH THE ACCELERATORS. ALL FUNNEL FLUID AND ELECTRICAL LINES MUST PENETRATE THE FORWARD CLOSURE SO THEY DO NOT NEED TO BE BROKEN EVERY TIME THE VESSEL IS REMOVED. BOTH THE FORWARD CLOSURE AND THE VACUUM VESSEL ARE MOUNTED ON 2-4 ACME THREAD VERTICAL ADJUSTORS SIMILAR TO THOSE USED ON CDTL. CARBON STEEL BOX BEAM SUPPORT STANDS WILL BE CONSTRUCTED TO HOLD BOTH THE VESSEL AND THE CLOSURE. LARGE, 8 INCH DIAMETER, CASTERING PHENOLIC WHEELS WILL PROVIDE THE NEEDED MOBILITY FOR THE VESSEL, AND THE FORWARD CLOSURE PRIOR TO ITS PERMANENT POSTIONING.

TBF EXPERIMENT ASSEMBLY



McDonnell Douglas Missile Systems Company

TBF FORWARD CLOSURE

THE FORWARD CLOSURE TO THE TBF VACUUM VESSEL ACCOMODATES SEVERAL DIFFERENT FUCTIONS:

1. SERVES AS THE PHYSICAL INTERFACE BETWEEEN THE ACCELERATORS AND THE FUNNEL.

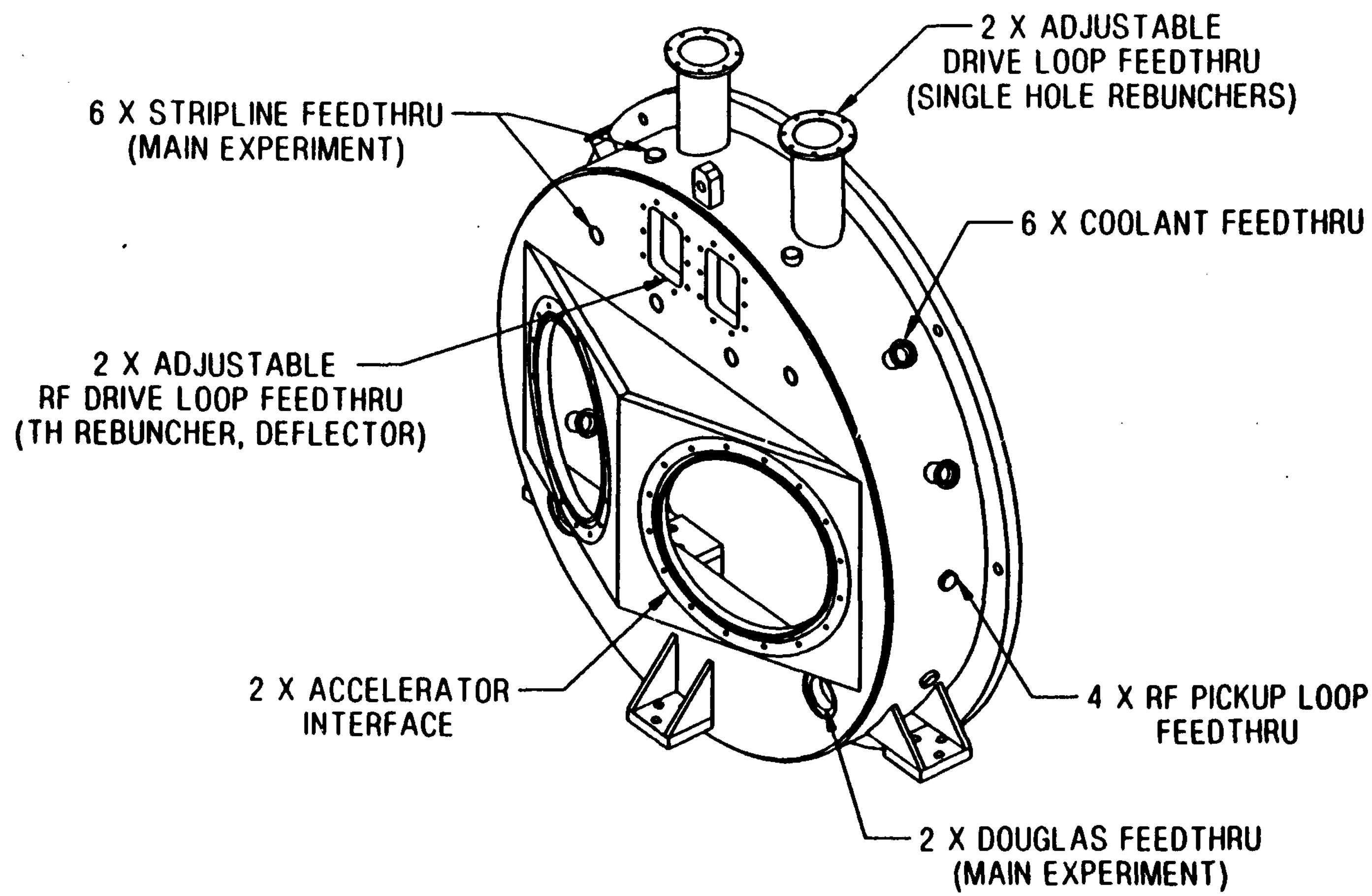
2. IT IS THE MAIN STRUCTURAL SUPPORT FOR THE CANTILEVERED OPTICAL BENCH.

3. MUST CONTAIN ALL VACUUM FEEDTHRUS FOR THE FUNNEL PORTION OF THE EXPERIMENT. THESE INCLUDE:

   a. 2 X 50 WIRE DUCTOR SEAL ELECTRICAL FEEDTHRUS
   b. 4 X RF DRIVE LOOP FEEDTHRUS
   c. 4 X RF FEEDBACK LOOP FEEDTHRUS
   d. 6 X COOLANT LOOPS
   e. 6 X STRIPLINE DETECTOR FEEDTHRUS

THE ENGINEERING DRAWING WAS COMPLETED 07 SEPT 89 AND IS CURRENTLY IN THE BID CYCLE. THE EXPECTED DELIVERY DATE IS 15 FEB 90.

TBF FORWARD CLOSURE

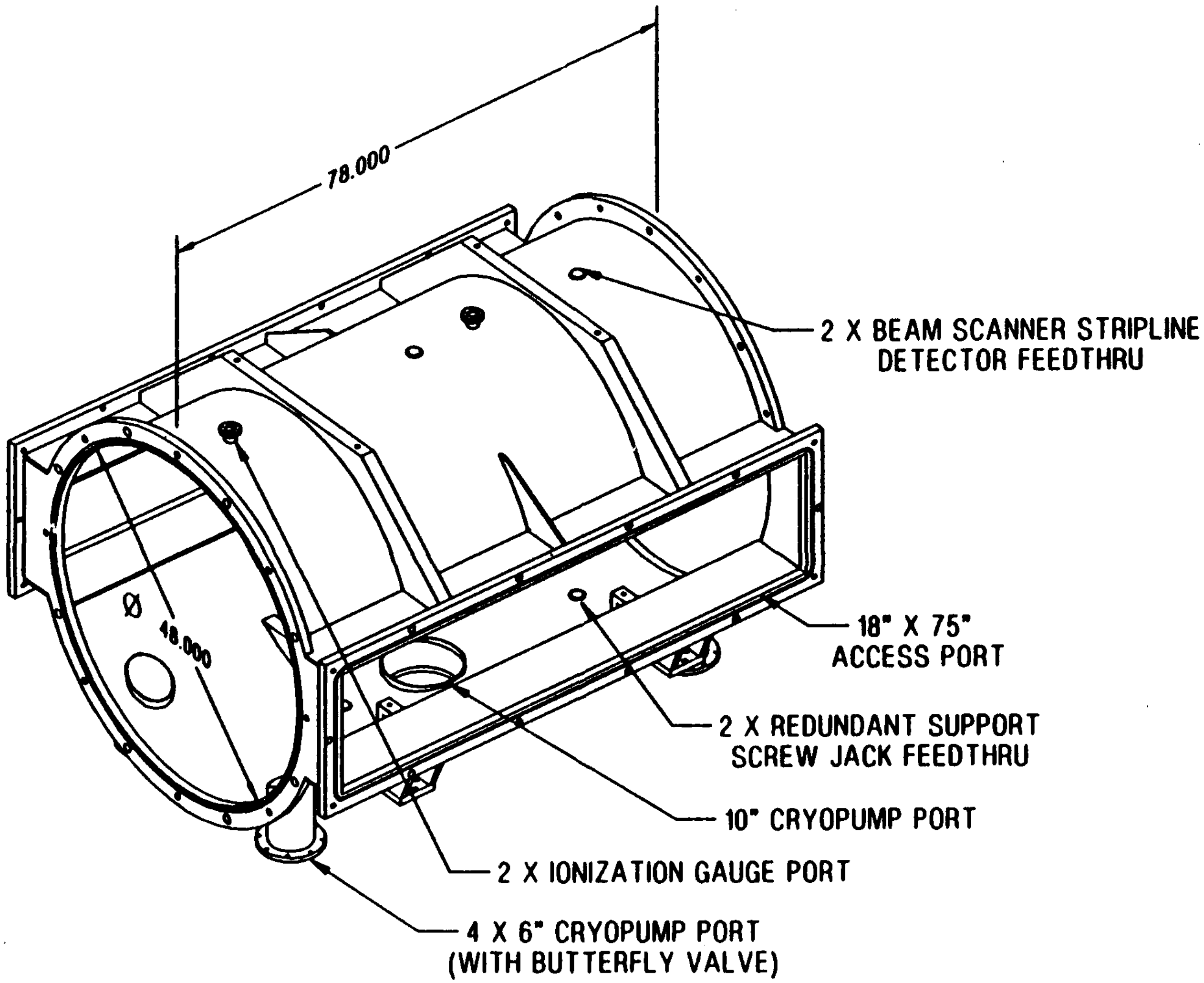


McDonnell Douglas Missile Systems Company

TBF VACUUM VESSEL

THE TBF VACUUM VESSEL IS 78 INCHES LONG WITH A 48 INCH INNER DIAMETER. FOR EASE OF ACCESS AND ALIGNMENT WHEN THE VESSEL IS IN PLACE, AN 18 INCH HIGH PORT RUNS THE FULL LENGTH OF THE VESSEL ON EACH SIDE. FOUR 6 INCH AND ONE 10 INCH CRYOPUMP PORTS ARE LOCATED ON THE BOTTOM OF THE VESSEL. IN ADDITION, TWO NW 50 KWIK FLANGES WILL PROVIDE SOCKET WRENCH ACCESS TO THE TWO REDUNDANT SUPPORT JACKS. AN IONIZATION GAUGE WILL BE LOCATED ON EACH OF THE TWO CONFLAT FLANGES ON TOP OF THE VESSEL. THE TWO BEAM SCANNER STRIPLINE DETECTORS WILL ALSO PENETRATE THE VESSEL. THE VACUUM VESSEL ENGINEERING DRAWING WAS COMPLETED 24 AUG 89, AND IS CURRENTLY IN THE BID CYCLE. SIX PROJECT SPECIFIED VENDORS HAVE RECEIVED PACKAGES. THE EXPECTED DELIVERY DATE IS 15 FEB 90.

TBF VACUUM VESSEL



McDonnell Douglas Missile Systems Company

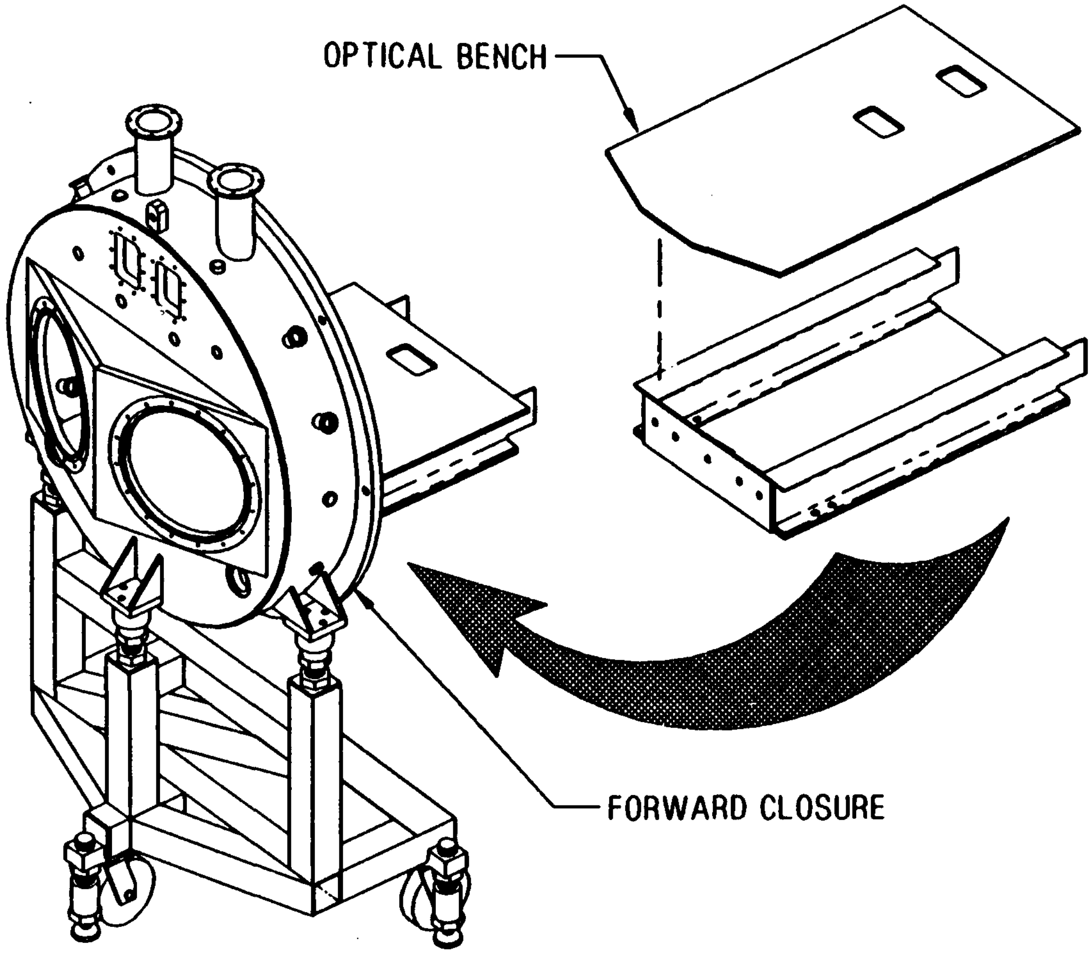
TBF EXPERIMENT (EXPOSED)

THE TWO BEAM FUNNEL EXPERIMENT IS SHOWN AS IT WILL BE CONFIGURED FOR OPTICS INTEGRATION. THE OPTICAL BENCH IS CANTILEVERED OFF OF THE FORWARD CLOSURE. IT IS CONSTRUCTED OF TWO 6061 1/2 INCH PLATES SEPARATED BY TWO 6061, 6 INCH, WIDE FLANGE I-BEAMS. THIS DESIGN LIMITS THE MAXIMUM DEFLECTION OF THE OPTICS TO LESS THAN .0005 INCH. WHEN THE VACUUM VESSEL IS REPLACED, THE FREE END OF THE OPTICAL BENCH WILL BE REDUNDANTLY SUPPORTED BY A SCREW JACK ASSEMBLY. THIS ENABLES THE BEAM SCANNER AND OTHER DIAGNOSTICS TO BE ADDED TO THE EXPERIMENT WITHOUT INDUCING ADDITIONAL DEFLECTIONS TO THE OPTICS. THE TWO LARGE HOLES CUT IN THE TOP PLATE OF THE OPTICAL BENCH ARE CLEARANCE HOLES FOR THE TWO HOLE REBUNCHER AND THE RF DEFLECTOR.

21 SEPT 89

TBF EXPERIMENT (EXPOSED)

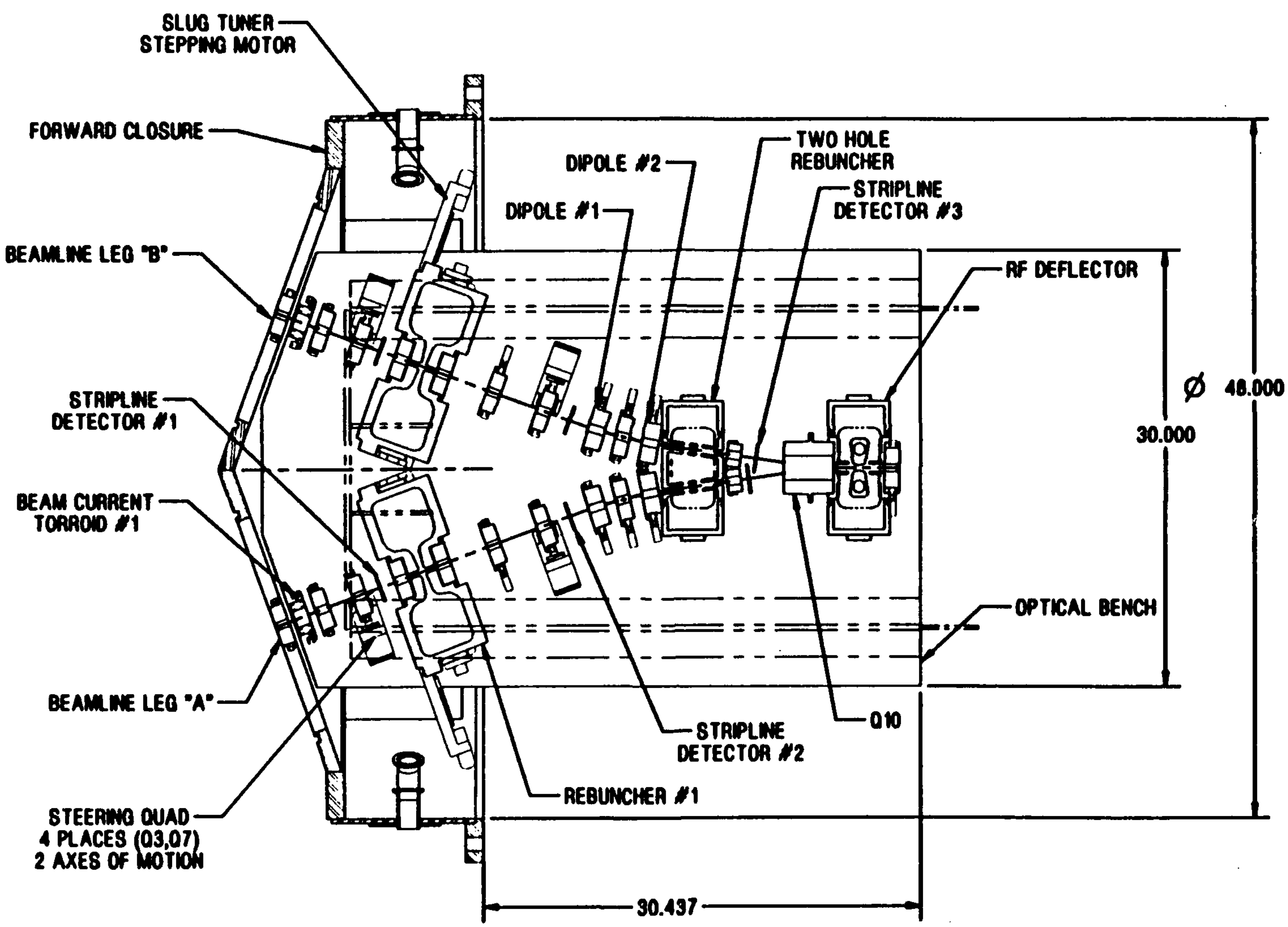
(VACUUM VESSEL ROLLED AWAY)



TBF BEAMLINE OPTICS

THE FUNNEL IS SHOWN AS IT WILL APPEAR WITH THE VESSEL REMOVED. THE TWO HOLE REBUNCHER AND DEFLECTOR DESIGNS HAVE CHANGED SINCE THE PDR AND THE CURRENT CONFIGURATIONS REFLECTED HERE. THE POSITIONS OF THE BEAMLINE DIAGNOSTICS ARE ALSO SHOWN. NOTE STRIPLINE #3 IS LOCATED AT A DIFFERENT AXIAL POSITION IN EACH LEG. THEREFORE, THEY CANNOT BE USED TO OBTAIN RELATIVE PHASING INFORMATION. THIS DATA WILL HAVE TO COME FROM EITHER STRIPLINES #1 OR #2. MAGNETS Q1 AND Q2 ALONG WITH BEAM CURRENT TORROID #1 WILL ALL BE MOUNTED FROM THE SAME SUPPORT, DUE TO THIER CLOSE RELATIVE POSITIONS. QUADRUPOLES Q3 AND Q7 ARE STEERING ELEMENTS AND ARE REMOTELY ADJUSTABLE IN 2 AXES.

BEAMLINE OPTICS

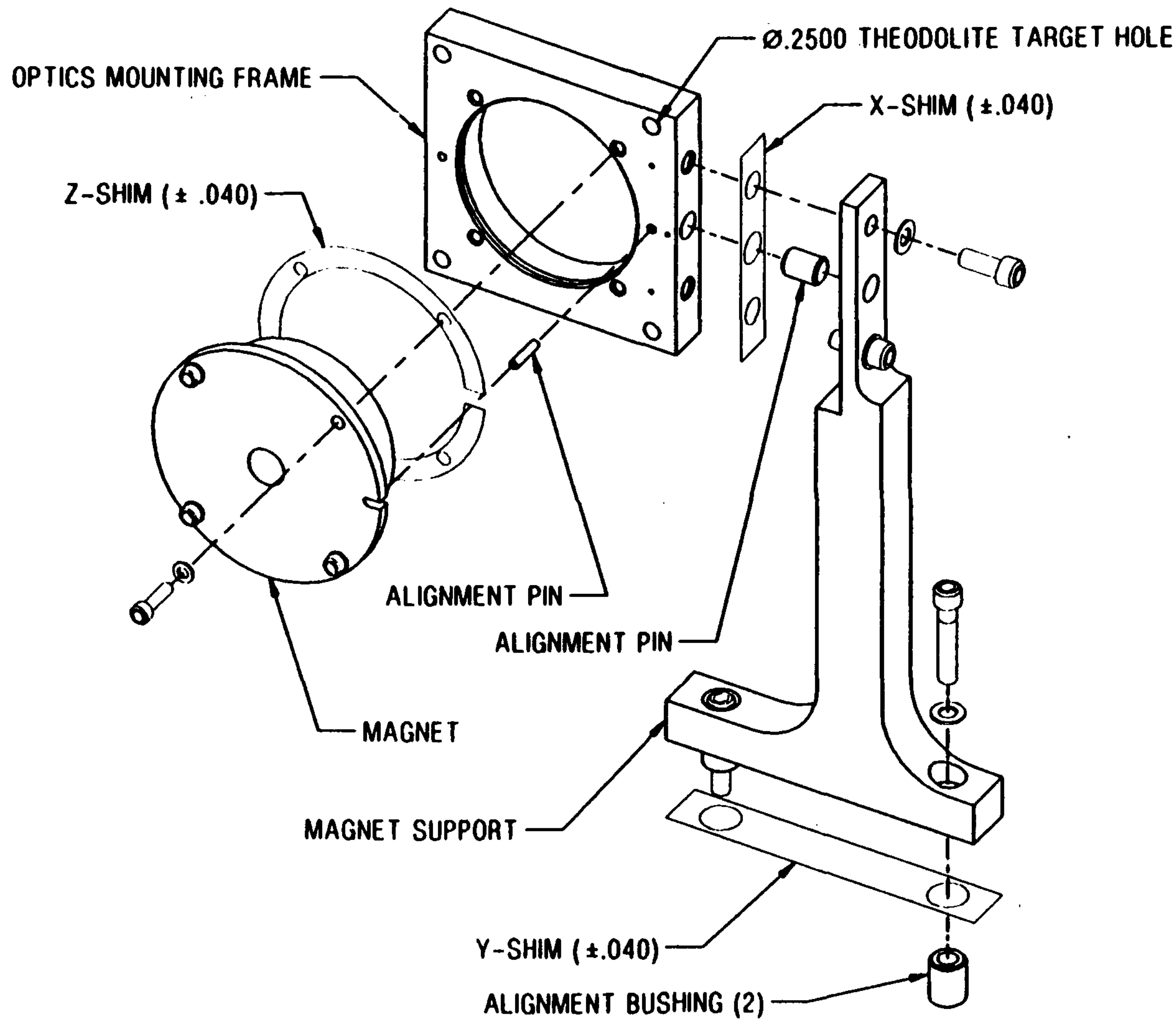


TBF OPTICS MOUNT

THE TBF OPTICS MOUNT DESIGN IS BASED ON THE MBFE APPROACH. THE PRECISION OUTER DIAMETER OF THE MAGNET IS SLIPPED INTO THE CLOSE TOLERANCE HOLE OF THE MAGNET FRAME. THE UNIT IS THEN ALIGNED VIA THE FOUR THEODOLITE TARGET HOLES. THE SHIMS ALLOW THE UNIT TO BE ACCURATELY POSITIONED IN JUST ONE ITTERATION. THE GENERAL CONFIGURATION SHOWN WILL ONLY BE USED ON MAGNETS D1, Q6, Q8, Q11. ALL OTHERS WILL REQUIRE MODIFICATIONS OF THE BASIC DESIGN. THE MAGNET FRAME WILL BE COMMON TO ALL THE MAGNETS, EXCEPT Q4 AND Q5 WHICH ARE INTERNAL TO THE REBUNCHER, AND Q9 AND Q10 WHICH HAVE DIFFERENT OUTSIDE DIAMETERS. THE FRAME HOLDING D2 WILL HAVE ITS INBOARD CORNER CHAMFERED, DUE TO AN INTERFERENCE PROBLEM. ALTHOUGH COMMONALITY BETWEEN MAGNET SUPPORTS MAY BE LOW, SIMILARITY IS HIGH, WHICH WILL GREATLY REDUCE THE DESIGN/DRAWING PREPARATION TIME.

21 SEPT 89

TBF OPTICS MOUNT



McDonnell Douglas Missile Systems Company

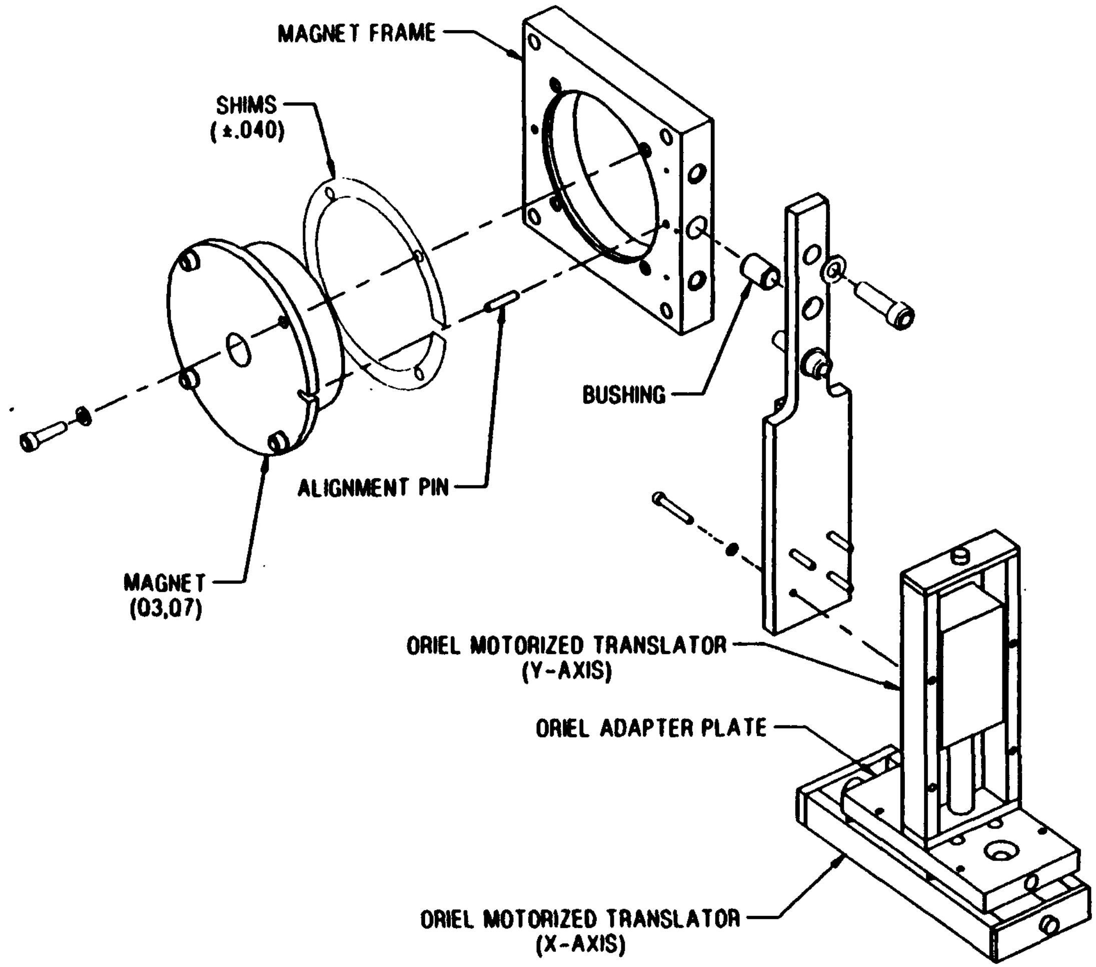
STEERING QUADRUPOLES

OPTIMAL POSITIONS FOR THE STEERING ELEMENTS WERE DEFINED USING A BEAMLINE ERROR AND SENSITIVITY ANALYSIS. IT DETERMINED TWO AXES OF ADJUSTABILITY AT QUADS Q3 AND Q7 WOULD PROVIDE THE GREATEST DEGREE OF BEAM STEERING. ORIEL MINIATURE MOTORIZED TRANSLATORS, MODIFIED FOR VACUUM SERVICE, WERE CHOSEN OVER PRINCETON MOTORIZED SLIDES FOR SEVERAL REASONS:

1. COMPACT DESIGN
2. OPTICAL ENCODER SHAFT DOES NOT REQUIRE AN ADDITIONAL LVDT
3. EASILY CONFIGURED FOR TWO AXES ADJUSTMENT USING A STANDARD ORIEL ADAPTER PLATE.

THE ORIEL TRANSLATORS HAVE A UNIDIRECTIONAL REPEATABILITY OF ±.00001 INCH AND EXCERT A MAXIMUM AXIAL FORCE OF 22 POUNDS.

TBF STEERING QUADRUPOLES

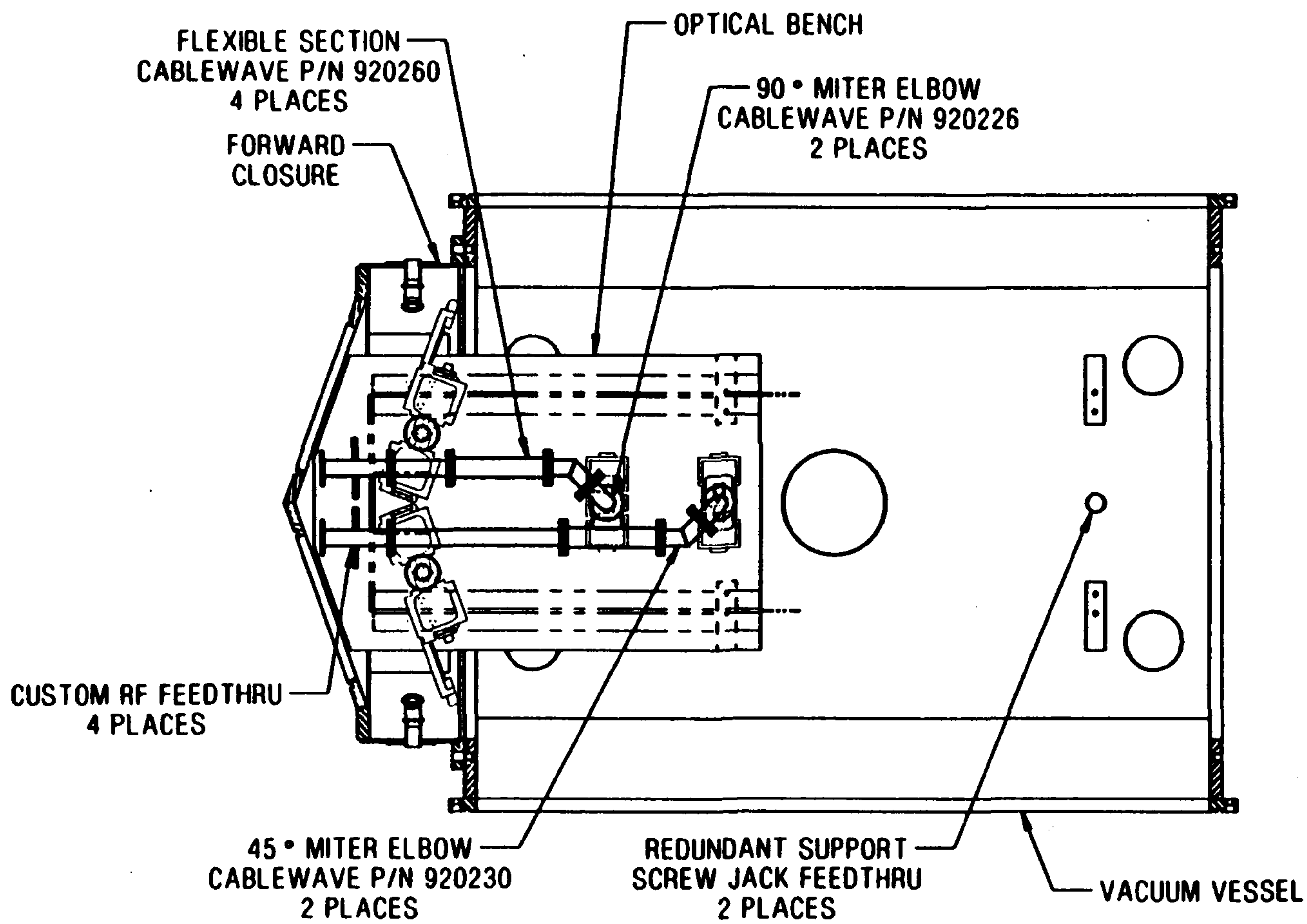


McDonnell Douglas Missile Systems Company

RF COAX LAYOUT

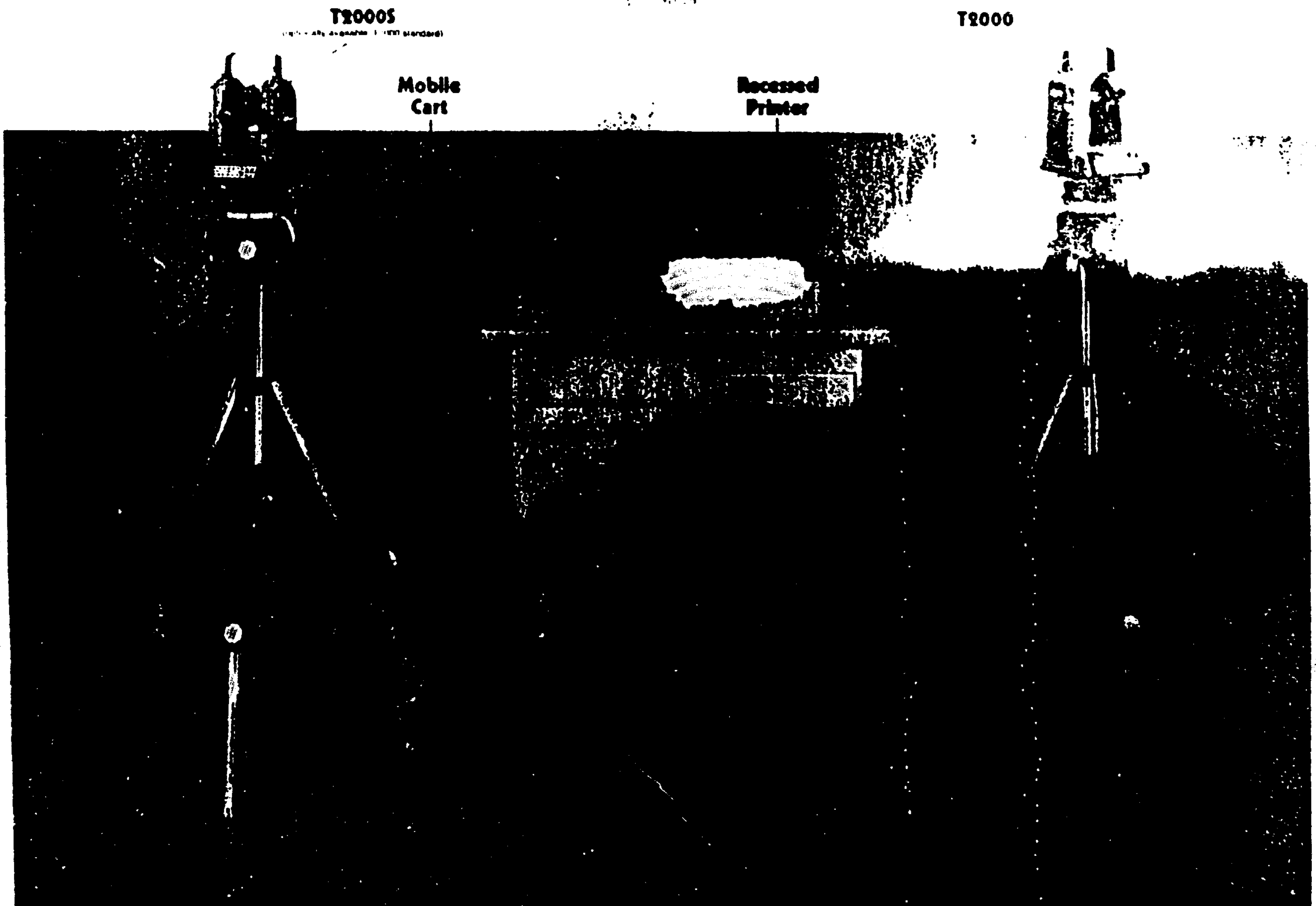
RF DRIVE LOOP COAX RUNNING FROM THE RF CAVITIES THRU THE VACUUM WALL IS ROUTED AS SHOWN. THE ACCSYS/MDMSC INTERFACE OCCURS AT THE GAS BARRIER, WHICH IS LOCATED ONE HALF WAVELENGTH FROM ITS RESPECTIVE DRIVE LOOP. ADJUSTABLE VACUUM FEEDTHRUS HAVE BEEN DESIGNED WHICH DO NOT REQUIRE THE EXACT LOCATION OF THIS INTERFACE TO BE DETERMINED UNTIL LATER IN THE PROGRAM. THE FEEDTHRUS ALLOW FOR A ±1.813 INCH VARIATION IN INTERFACE LOCATION. THIS ALLOWS TIME FOR THE DESIGN, TUNING AND TESTING OF THE RF CAVITIES. ACCSYS WILL PROVIDE THE GAS BARRIER, AND THIER PORTION OF THE LINE WILL BE EVACUATED, WHILE MDMSC'S PORTION WILL BE PRESSURIZED. THE COAX WILL BE 1 5/8 RIGID 50 OHM LINE. EACH OF THE FOUR LINES WILL CONTAIN A FLEXIBLE SECTION TO ACCOUNT FOR LINE LENGTH CHANGES DUE TO THERMAL EXPANSION AND VACUUM LOADING.

RF COAX LAYOUT



COMPUTERIZED THEODOLITE SYSTEM

THE WILD-LEITZ MODEL T2000 COMPUTERIZED THEODOLITE SYSTEM WILL BE USED TO ALIGN THE TWO BEAM FUNNEL EXPERIMENT. IT UTILIZES THREE DIMENSIONAL TRIANGULATION TO LOCATE A GIVEN POINT IN SPACE WITH RESPECT TO ANOTHER REFERENCE POINT. THE SYSTEM IS LIMITED TO AN INCLUDED ANGLE BETWEEN THEODOLITES OF 60 TO 120 DEGREES, BUT IS MOST ACCURATE AT 90 DEGREES. WITHIN THIS RANGE IT IS ACCURATE TO .001 INCH OVER A 6 FOOT DISTANCE. WITH THREE POINTS ON A GIVEN PART, ANGULAR ACCURACY CAN BE DETERMINED. AS CURRENTLY DESIGNED, THE SYSTEM WILL BE ABLE TO DETERMINE THE ANGLE OF A GIVEN MAGNET FRAME TO WITHIN 0.6 mRAD.



Reproduced From
Best Available Copy

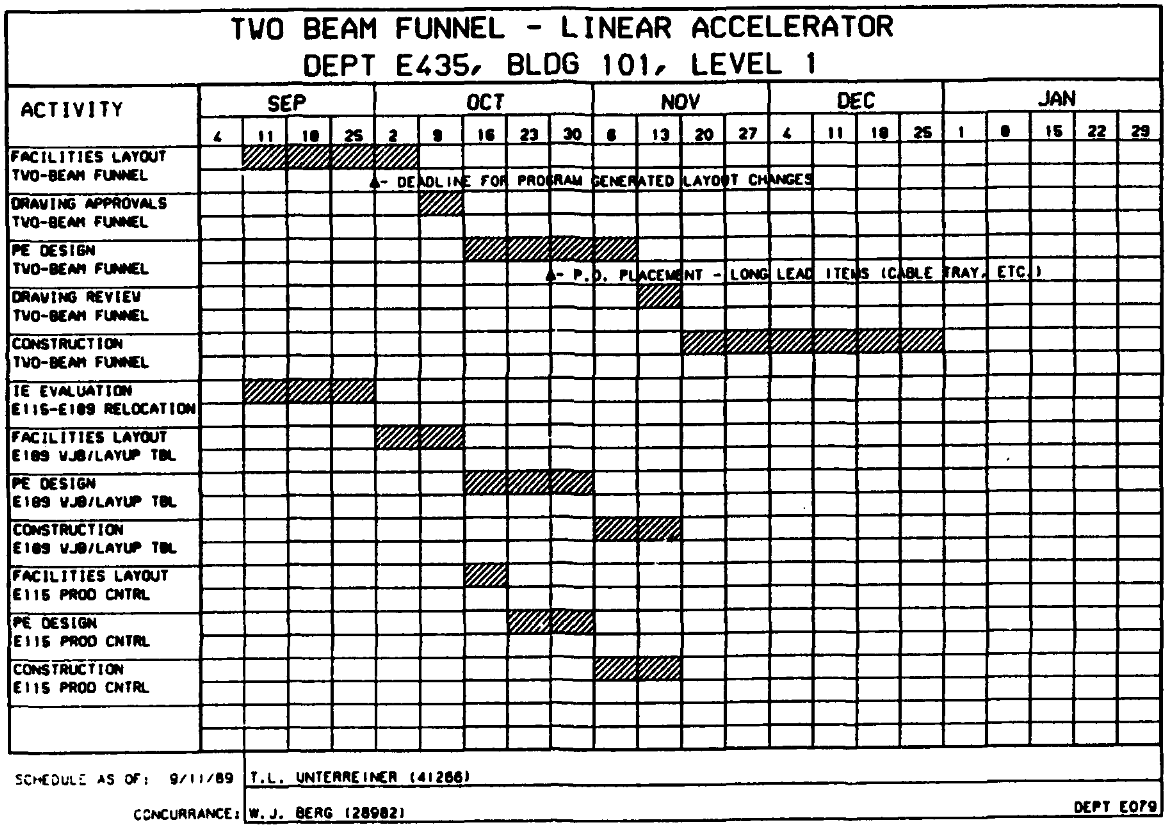
21SEP89
TBF064.FDR

FACILITY STATUS

ART LOWELL

McDonnell Douglas Missile Systems Company

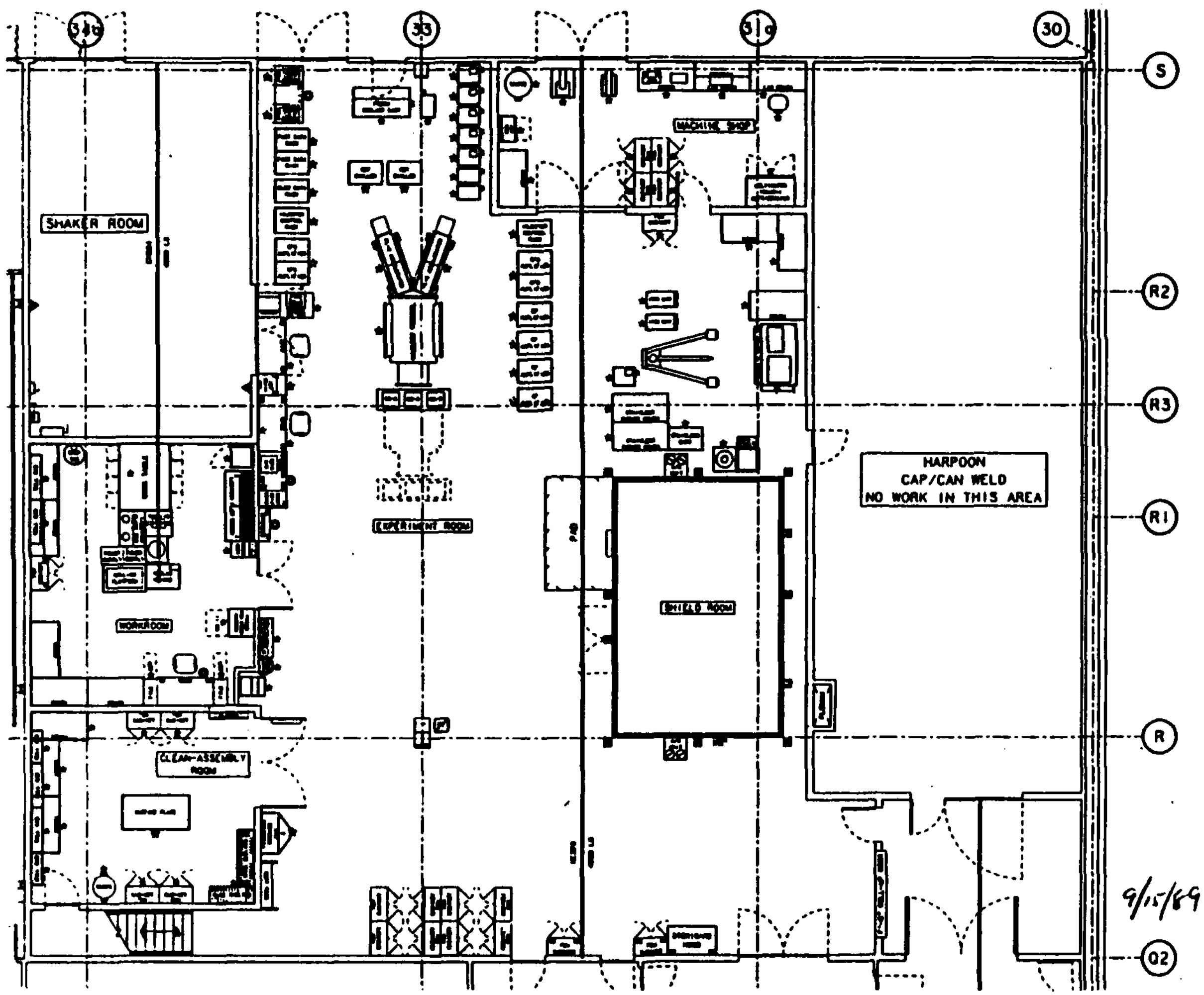
TBF FACILITIES SCHEDULE



TWO-BEAM FUNNEL FACILITY FLOOR PLAN

- FACILITY HAS FIVE MAJOR AREAS
  - TBF EXPERIMENT AREA
  - INJECTOR SHIELD ROOM
  - GENERAL ASSEMBLY WORKSHOP
  - MACHINE SHOP
  - CLEAN ASSEMBLY AREA
- ISOLATED FACILITY DEDICATED SOLELY TO NUCLEAR TECHNOLOGY PROGRAMS

TBF FACILITY FLOOR PLAN

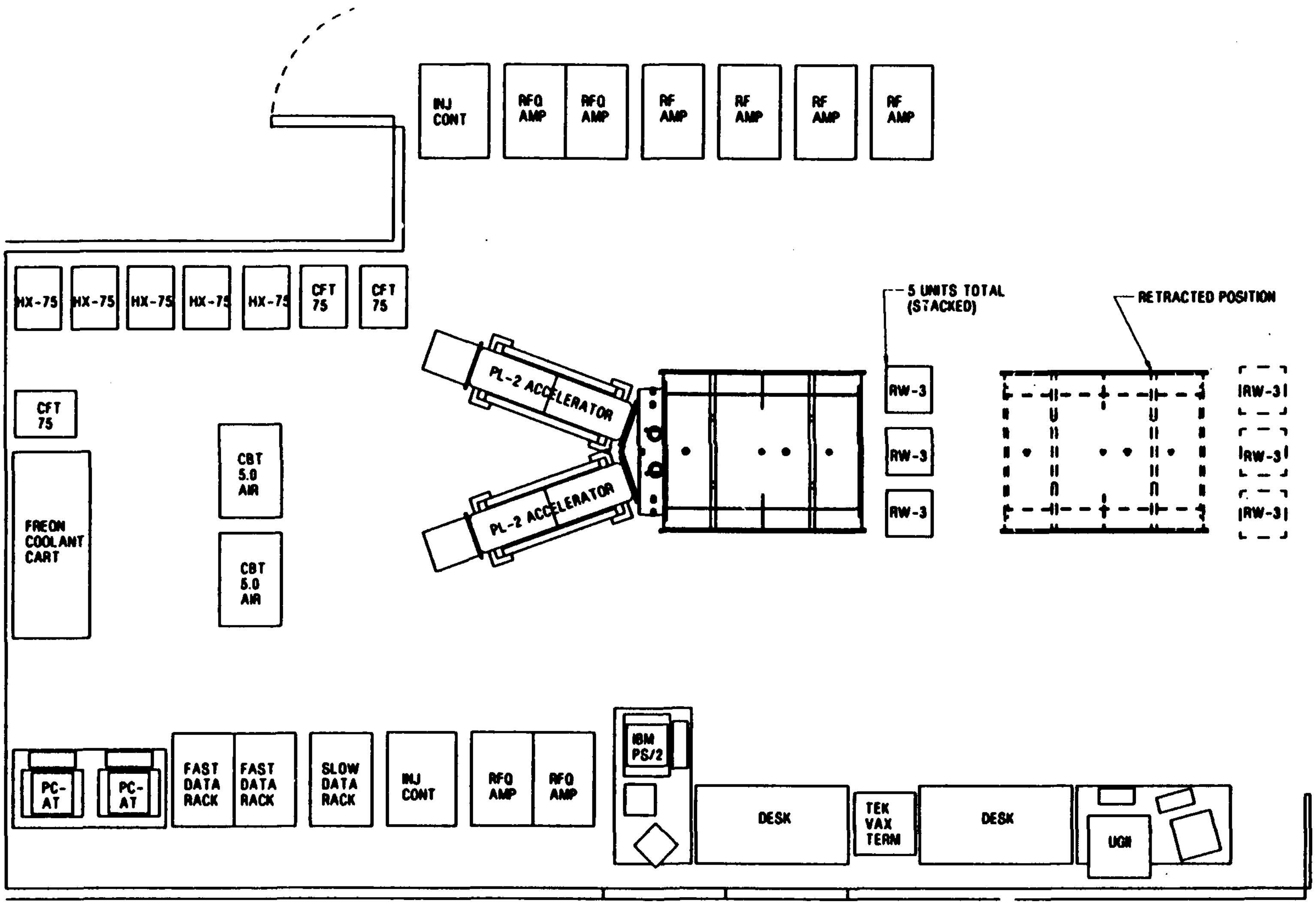


McDonnell Douglas Missile Systems Company

TWO-BEAM FUNNELING EXPERIMENT LAYOUT

- CLEAR ACCESS TO ALL BEAMLINE COMPONENTS
- ALL CABLING AND PLUMBING MOUNTED OVERHEAD
- CONTROL STATION HAS
    - EXPERIMENT HOST COMPUTER
    - VAX TERMINAL FOR OPTICS CODE COMPARISON
    - UNIGRAPHICS TERMINAL FOR DESIGN INFORMATION

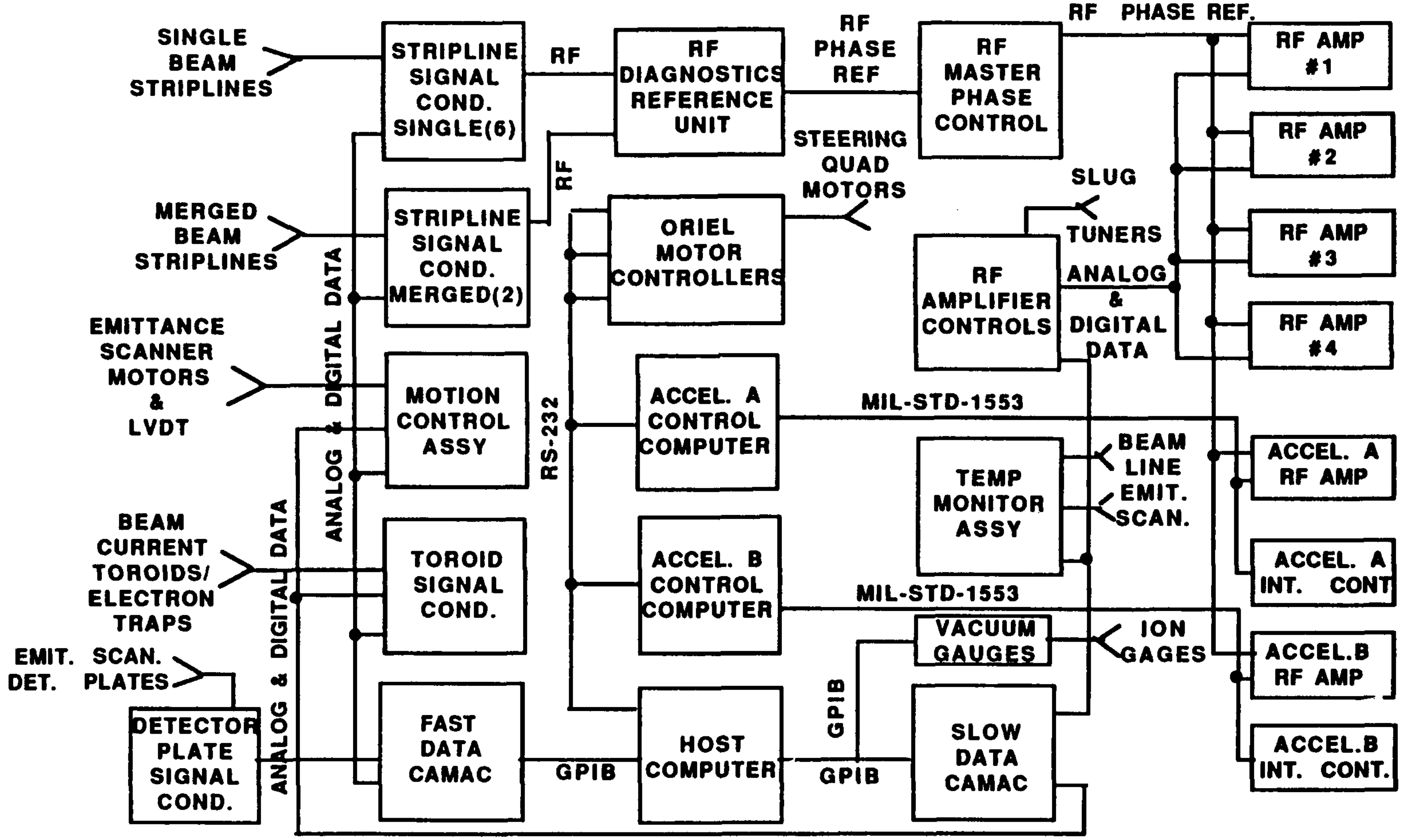
TWO BEAM FUNNELING LAYOUT



MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY

POWER & CONTROL SYSTEM BLOCK DIAGRAM

21SEP89
TBF137.FDR



McDonnell Douglas Missile Systems Company

FAST DATA CAMAC CRATE

- CRATE ------------ KINETIC SYSTEMS MODEL 1502
- CONTROLLER --- LeCROY 6010 INTELLIGENT CONTROLLER
- MODULES -------- 2 x LeCROY 6810 FAST ADC
  4 x JORWAY AURORA 12 TRANSIENT RECORDER
  2 x LeCROY 8212A ADC
  2 x LeCROY 8800A MEMORY FOR 8212A
  2 x JORWAY 221 TIMER & SEQUENCER
  2 x JORWAY 222 OUTPUT BUFFER FOR 221

SLOW DATA CAMAC CRATE

- CRATE ——— KINETIC SYSTEMS MODEL 1502
- CONTROLLER —— LeCROY 6010 INTELLIGENT CRATE CONTROLLER
- MODULES ——— 1 x LeCROY 8212A ADC

  2 x JORWAY MODEL 232 DAC

  2 x JORWAY MODEL 41 TTL OUTPUT

  1 x KINETIC SYSTEMS 3471 TTL INPUT

RF DIAGNOSTICS

1 **MASTER PHASE CONTROLLER (AccSys, Inc.)**
Sets Phase & Frequency Reference for all RF Devices

1 **RF DIAGNOSTIC REFERENCE UNIT (MDMSC)**
Interfaces Master Phase Controller with Stripline Detector Signal Conditioners. Generates 850 MHz Phase Reference

6 **STRIPLINE SIGNAL CONDITIONER - SINGLE BEAM (MDMSC)**
Processes Output of Striplines 1 thru 3 in Each Beamline Upstream of Funnel

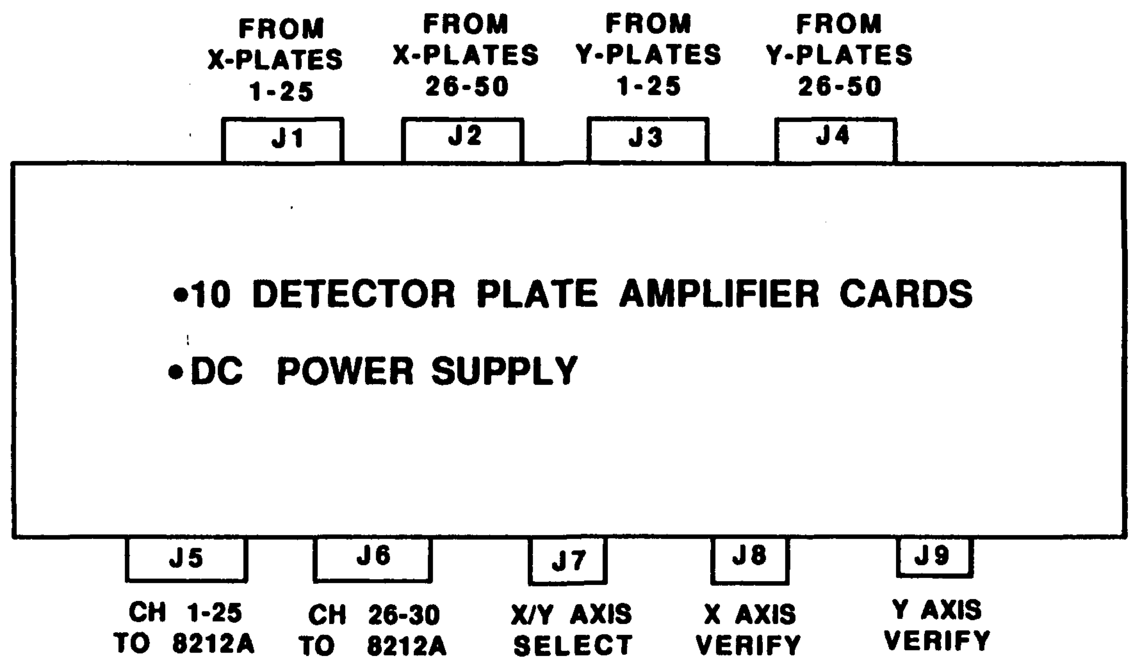
2 **STRIPLINE SIGNAL CONDITIONER - MERGED BEAMS (MDMSC)**
Processes Output of Striplines 4 and 5, Mounted on Emittance Scanner, After the Funnel. Processes Both 425 MHz and 850 MHz Information.

EMITTANCE SCANNER DETECTOR PLATE SIGNAL CONDITIONER

- MOUNTED ON VACUUM VESSEL SUPPORT STAND
- 100 GATED INTEGRATORS ON 10 PC CARDS
  (50 FOR EACH BEAM SCANNER AXIS)
- AXIS SELECT & VERIFY CONTROLLED BY CAMAC
- AXIS SELECTION AFTER INTEGRATORS

21SEP89
TBF123.FDR

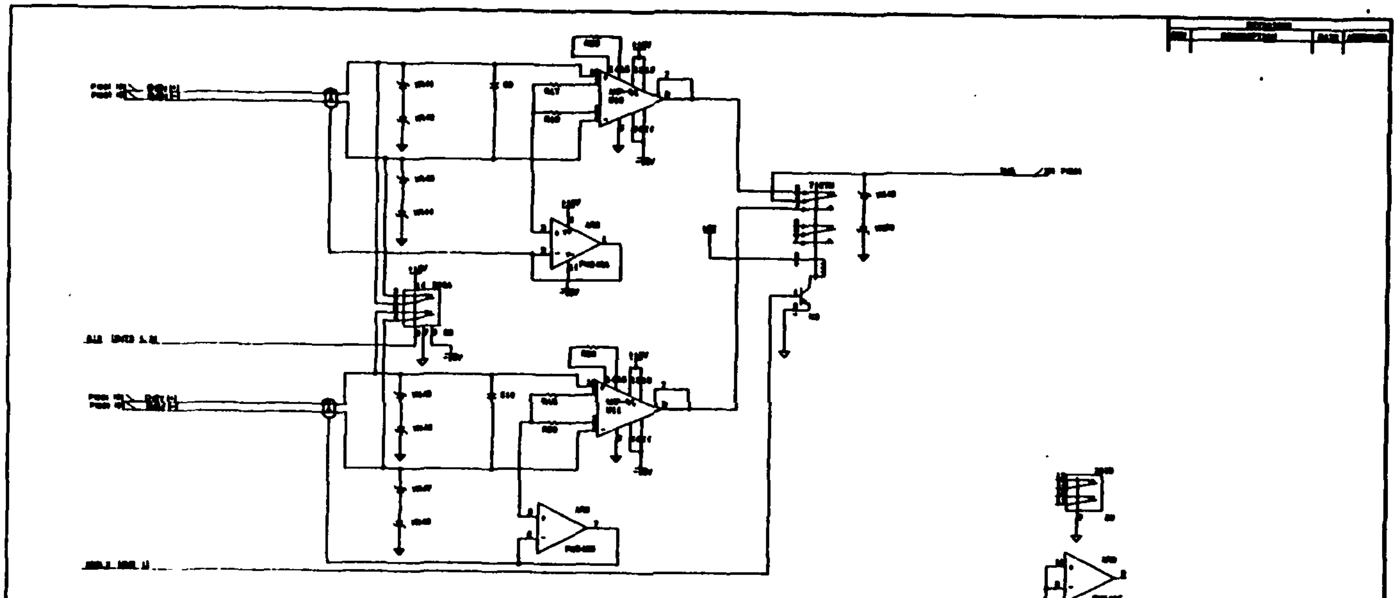
DETECTOR PLATE SIGNAL CONDITIONER ASSEMBLY



McDonnell Douglas Missile Systems Company

DETECTOR PLATE SIGNAL CONDITIONER SCHEMATIC

21SEP89
TBF152.FDR



SCANNER INTERFACE CKT
PARTS LIST

QTY	PART NUMBER	DESCRIPTION/MATERIAL	MANUFACTURER	CIRCUIT DESIGNATION
10	G12A103FCW	.01UF 30VDC 1% POLYCARB	COMP RESEARCH	C1-10
1	M39003/01-2766	10UF 20V TANT POLAR 10%	-QPL--M39003	C11
2	M39003/01-3007	10UF 35V 20% TANT-POLAR	-QPL--M39003	C12-13
39	M39014/01-1535	.01UF 100V 10% CERAMIC	-QPL--M39014	C14-52
30	RNC55J4991FR	4.99K 1% .1W METAL FILM	-QPL--RNC55	R1-30
50	TVS505	TRANSIENT VOLT SUPPRESSOR	UNITRODE	VR1-50
1	SN74HCT244J	HCT-OCTAL 3-STATE BUFFER	TI	U1
10	AMP-01EX	INSTRUMENTATION AMP	PMI	U2-11
3	HI1-0302-5	DUAL DPST CMOS ANALOG SW	HARRIS	S1-3
3	712TN-5	DPDT RELAY 5V COIL	TELEDYNE	K1-3
3	PM-248Y	QUAD 741 OP AMP	PMI	AR1-3

McDonnell Douglas Missile Systems Company

MOTION CONTROL ASSEMBLY

- MOTOR CONTROL

  SWITCHES MOTOR CONTROLLER TO SELECTED BEAMSCANNER AXIS

  SWITCHING DONE WITH T-BAR 24PDT LATCHING RELAY

  POSITION VERIFICATION FEEDBACK TO COMPUTER

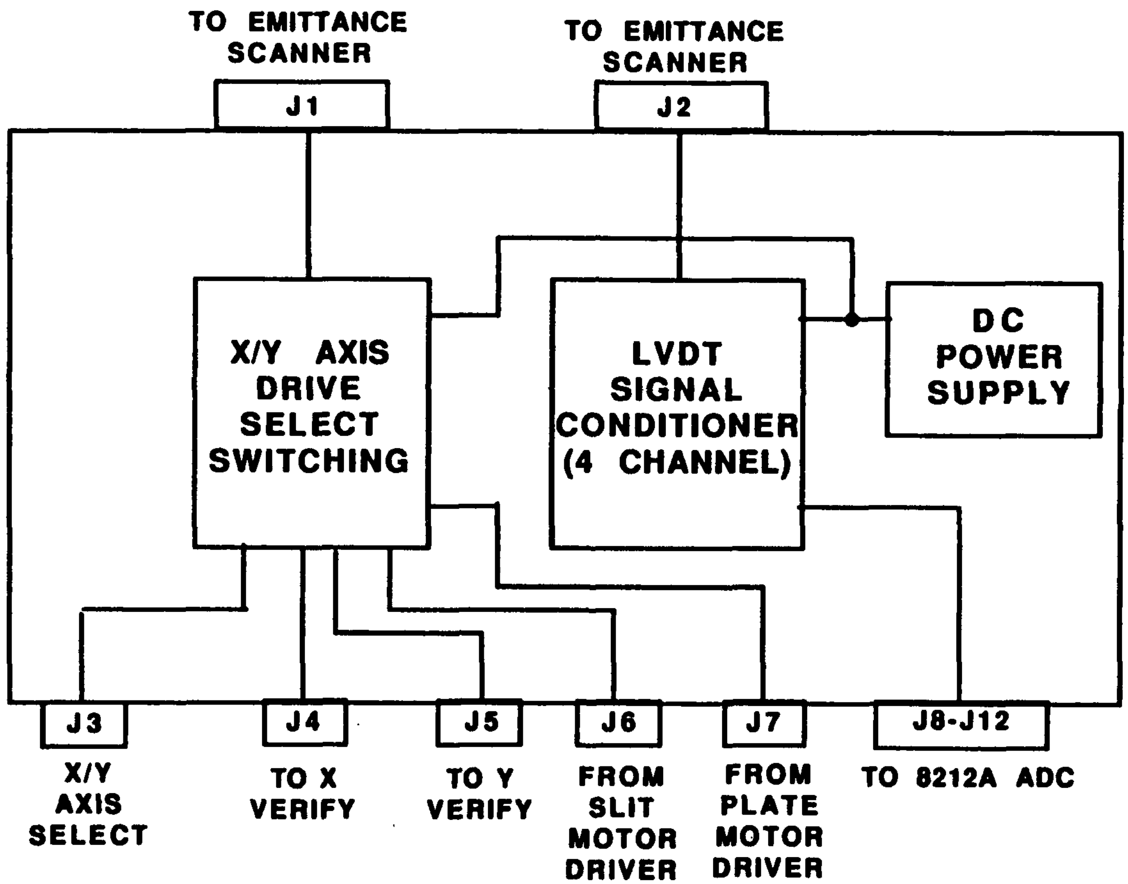
- LVDT SIGNAL CONDITIONER

  4 LOW PASS FILTER/BUFFER AMPLIFIERS FOR LVDTS

- COMMON +/- 15VDC POWER SUPPLY

21SEP89
TBF126.FDR

MOTION CONTROL ASSEMBLY



BEAM CURRENT TOROID SIGNAL CONDITIONER

TOROID SIGNAL CONDITIONER

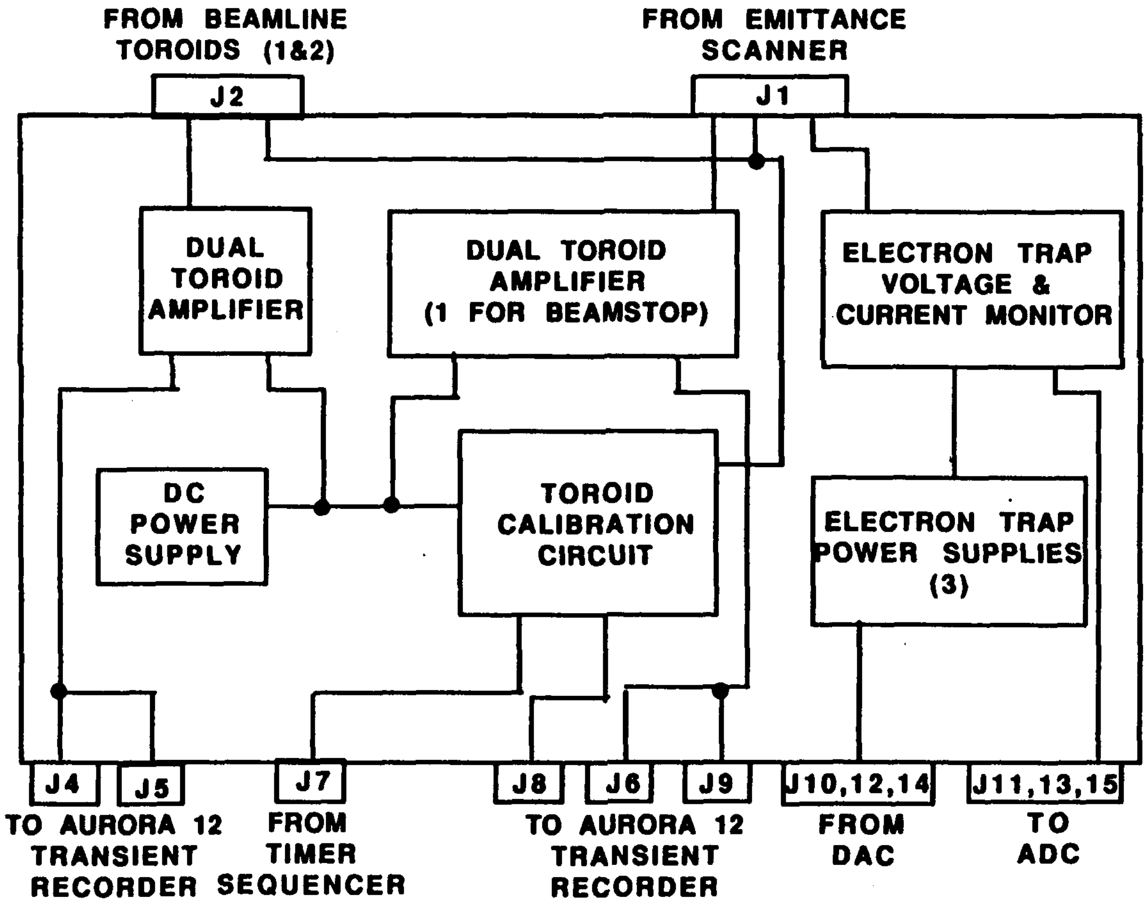
- 4 BEAR TOROID FILTER/AMPLIFIERS
- GATED CONSTANT CURRENT SOURCE FOR TOROID CALIBRATION

ELECTRON TRAP CONTROL

- 3 0-100VDC PROGRAMMABLE POWER SUPPLIES
- VOLTAGE AND CURRENT MONITORS FOR FEEDBACK TO COMPUTER

21SEP89
TBF127.FDR

BEAM CURRENT TOROID SIGNAL CONDITIONER



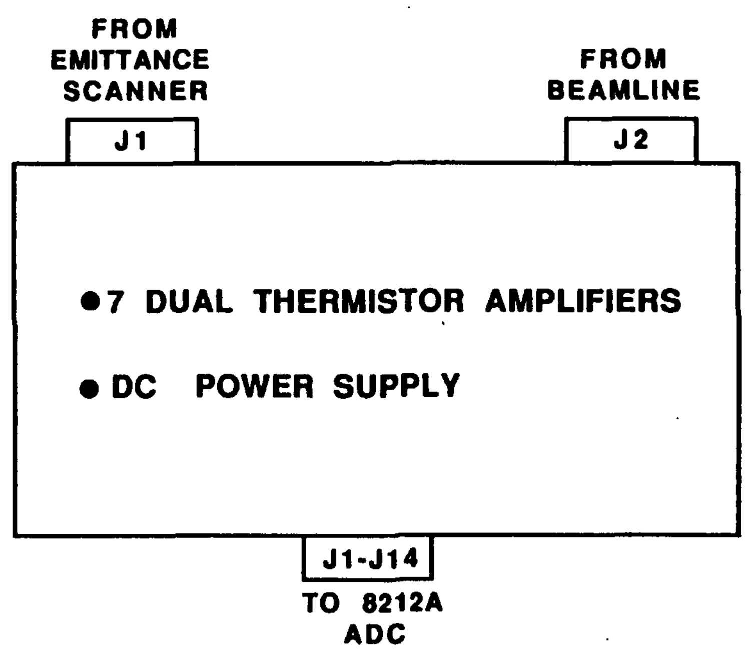
McDonnell Douglas Missile Systems Company

TEMPERATURE MONITOR ASSEMBLY

- USE DUAL RTD AMPLIFIERS FROM MASS II INJECTOR
- CHANGE BRIDGE VALUES FOR THERMISTORS
- 1B31AN STRAIN GAGE AMPLIFIER HAS PROGRAMMABLE GAIN AND LOW PASS FILTER
- MONITOR TEMPERATURE OF THE FOLLOWING:

  4 RF CAVITIES
  2 EMITTANCE SCANNER SLITS
  2 EMITTANCE SCANNER PLATES
  1 BEAMSTOP
  4 SLUG TUNER MOTORS

TEMPERATURE MONITOR ASSEMBLY



BEAM STEERING QUADRUPOLE CONTROLLER

3 ORIEL 188011 ENCODER MIKE CONTROLLERS WITH RS-232 INTERFACE

- EACH CONTROLLER RUNS 3 ORIEL 16727 MOTORIZED TRANSLATORS
- CONTROLLER INTERFACED TO HOST COMPUTER VIA RS-232 PORT
- CONTROLLERS PERFORM MOTION CONTROL, MONITOR POSITION, AND STORE POSITION DATA IN NON-VOLATILE MEMORY

ELECTRICAL FEEDTHRUS

- 5 MAJOR ELECTRICAL FEEDTHRUS
  - MANUFACTURED BY DOUGLAS ENGINEERING. SIMILAR TO BEAR FEEDTHRUS - TWO DESIGNS USED FOR TBF

    <u>CONFIGURATION 1</u>

    - 2 EMITTANCE SCANNER PLATE DATA - 50 TW/SH PAIR EACH

    <u>CONFIGURATION 2</u>

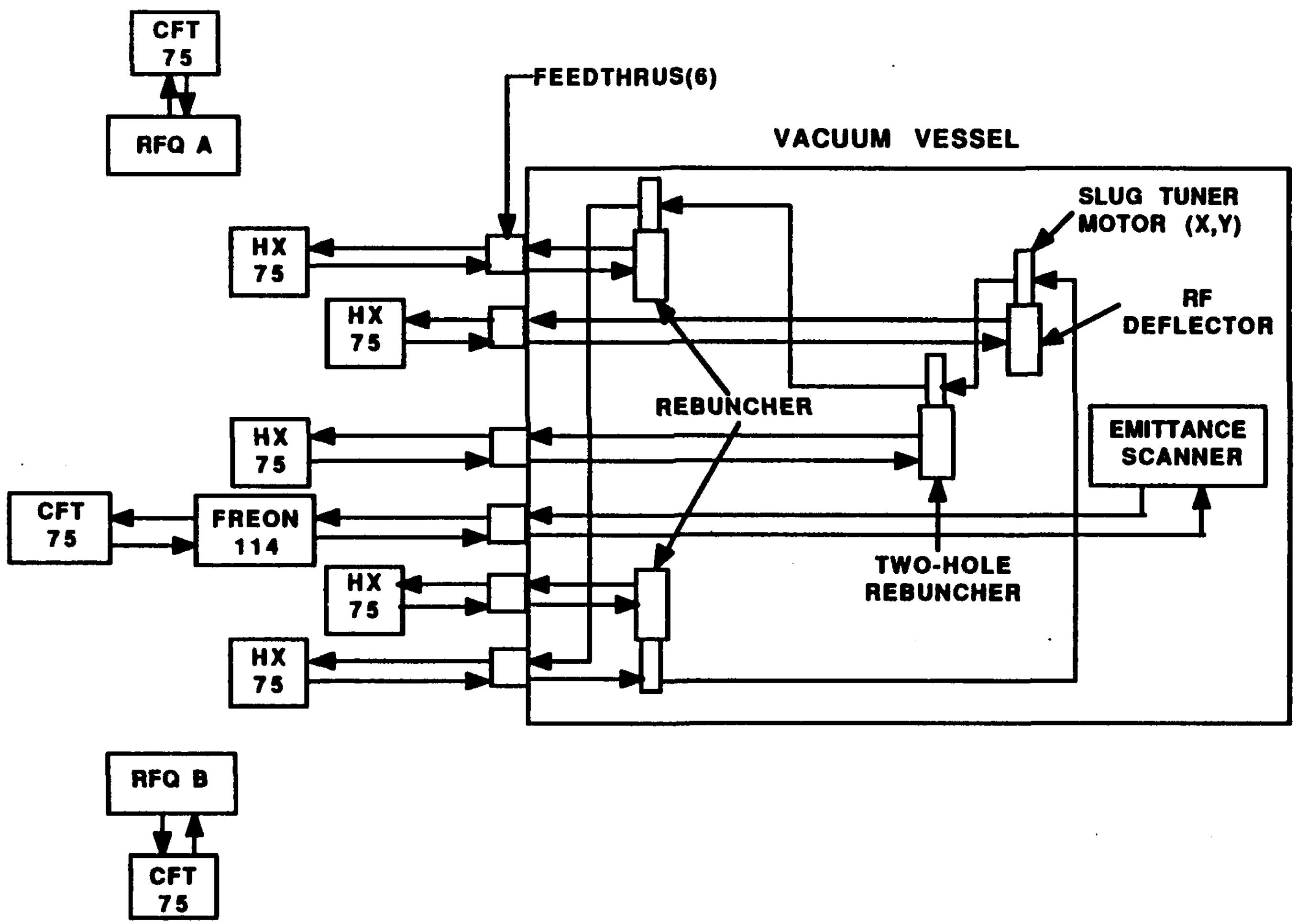
    - 1 EMITTANCE SCANNER UTILITIES - MOTOR CONTROL, LVDT DATA, TOROID DATA,TEMPERATURE MONITORS - MIXED WIRE TYPES
    - 1 RF CAVITY UTILITIES - SLUG TUNER DRIVES, TEMPERATURE MONITORS, MIXED WIRE TYPES
    - 1 BEAMLINE UTILITIES - STEERING QUAD DRIVE, TOROID DATA, TEMPERATURE MONITORS - MIXED WIRE TYPES
  - EXTRA LINES AVAILABLE ON 3 UTILITY FEEDTHRUS

TWO BEAM FUNNEL COOLANT SYSTEM

- EACH CAVITY HAS ITS OWN HX-75 CHILLER (GFE FROM MBFE)
- ALL SLUG TUNER DRIVE MOTORS ARE ON ONE HX-75 (GFE FROM MBFE)
- EACH RFQ HAS ITS OWN CFT-75 CHILLER (MDMSC CAPITAL)
- EMITTANCE SCANNER HAS FREON 114 SYSTEM SUPPORTED BY CFT-75 (MDMSC CAPITAL)

TWO BEAM FUNNEL COOLANT SYSTEM

21SEP89
TBF133.FDR



TWO BEAM FUNNEL VACUUM SYSTEM

- EACH ACCELERATOR HAS SELF-CONTAINED VACUUM SYSTEM

  2 CVI TM150 CRYOPUMPS - 1700 L/S N_2

  ISOLATION VALVES BETWEEN PUMPS AND CHAMBER AND BETWEEN INJECTOR AND RFQ

  VACUUM GAGES

  ROUGHING PUMP

- EXPERIMENT VACUUM VESSEL

  4 LEYBOLD 1500S2 CRYOPUMPS - 1500 L/S N_2

  1 LEYBOLD 3000S3 CRYOPUMP - 3000 L/S N_2

  ISOLATION VALVES BETWEEN PUMPS AND CHAMBER

  GRANVILLE-PHILLIPS ION AND CONVECTRON GAGES

  WELCH 1397 ROUGHING PUMP

21SEP89
TBF122.FDR

TWO BEAM FUNNEL VACUUM SYSTEM

SYSTEM DESIGNED FOR FAST UP-TO-AIR/BACK-TO-VACUUM
CRYOPUMP COMPRESSORS ARE MOUNTED ON A CART SO PUMPS CAN BE VALVED OFF AND LEFT ON-LINE WHILE VACUUM VESSEL IS ROLLED AWAY FROM EXPERIMENT

PRESCRIBED PUMPDOWN ROUTINE ALLOWS FAST RETURN TO VACUUM

ROUGH PUMP TO 10 Torr	30 minutes
N_2 SWEEP AT 10 Torr	15 minutes
ROUGH PUMP TO 2×10^{-2} Torr	40 minutes
CROSSOVER AT 2×10^{-2} Torr	
TOTAL TIME	1hr. 25 minutes

EXCESS CAPACITY ALLOWS PUMPS TO BE VALVED OFF AND REGENERATED ON A ROTATING BASIS WITHOUT INTERRUPTING THE EXPERIMENT

TWO BEAM FUNNEL GN_2 SYSTEM

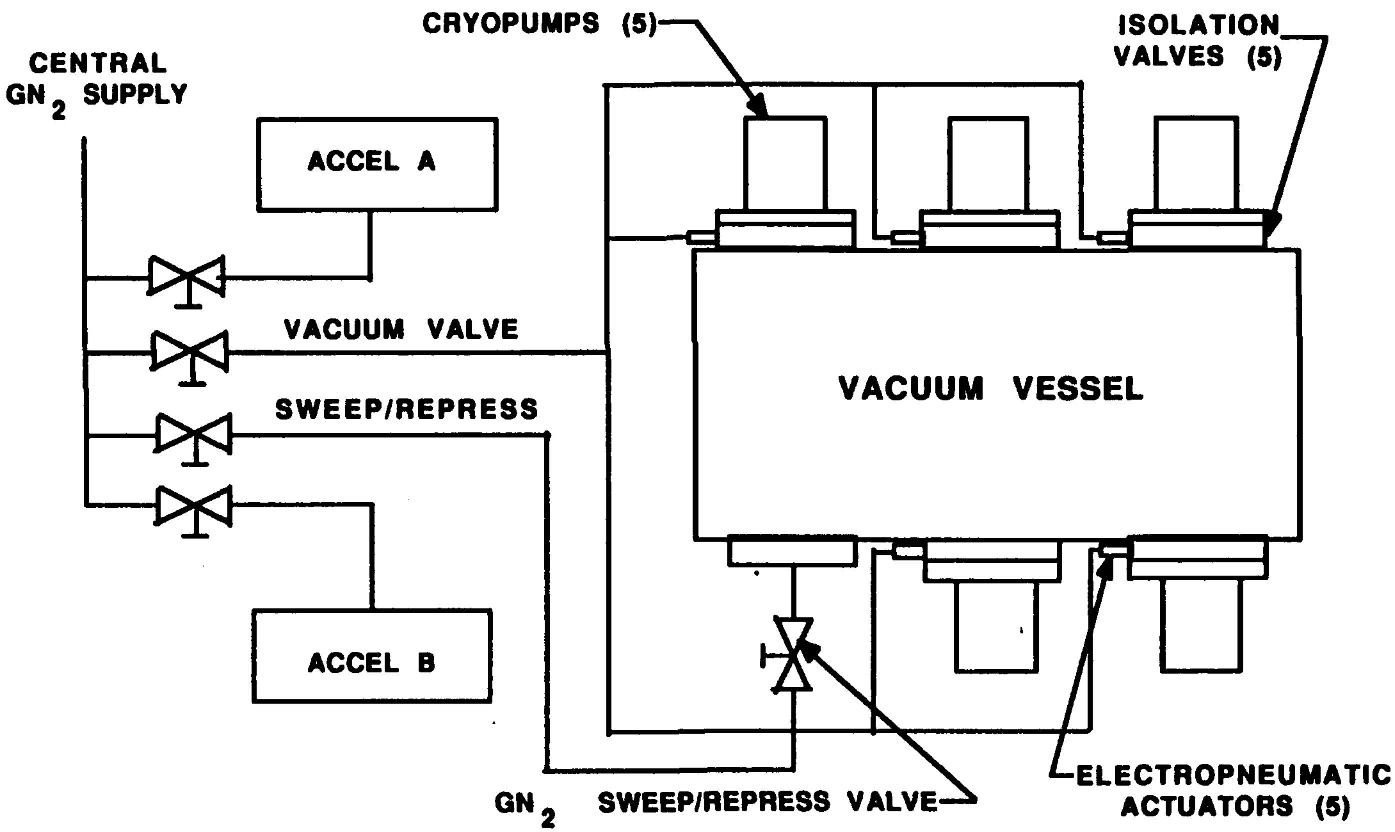
GN_2 SUPPLY FROM CENTRAL PLANT RESERVOIR

GN_2 USED FOR

- VACUUM CHAMBER SWEEP DURING ROUGH PUMPING TO REMOVE MOISTURE
- REPRESSURIZATION OF VACUUM CHAMBER
- VACUUM VALVE ACTUATOR DRIVE

21SEP89
TBF135.FDR

TWO BEAM FUNNEL GN_2 SYSTEM



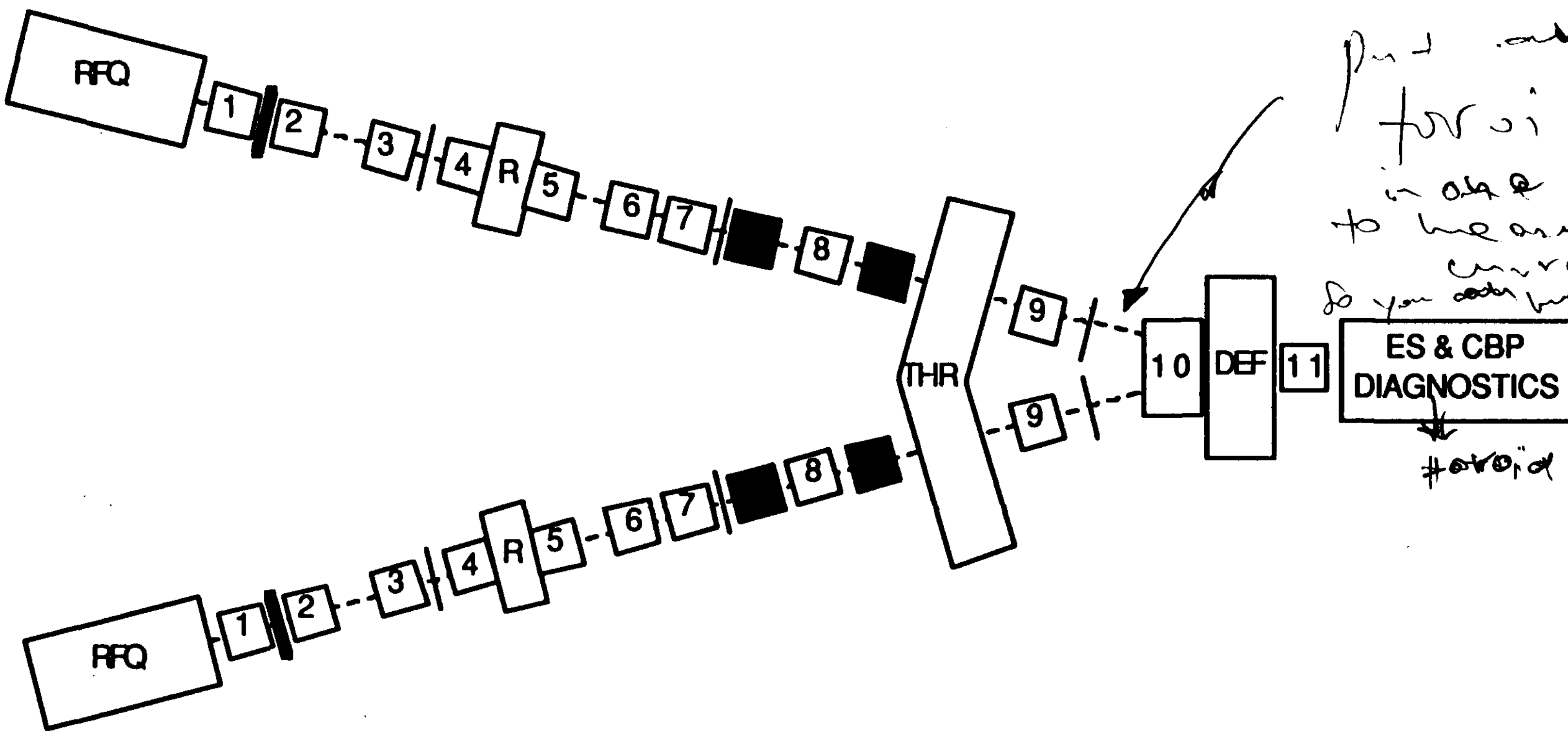
21SEP89
TBF065.FDR

DIAGNOSTICS

JIM BALLOU

McDonnell Douglas Missile Systems Company

DIAGNOSTIC LOCATIONS



Put another toroid in one beamline to measure current so you can measure beam loss in current

toroid

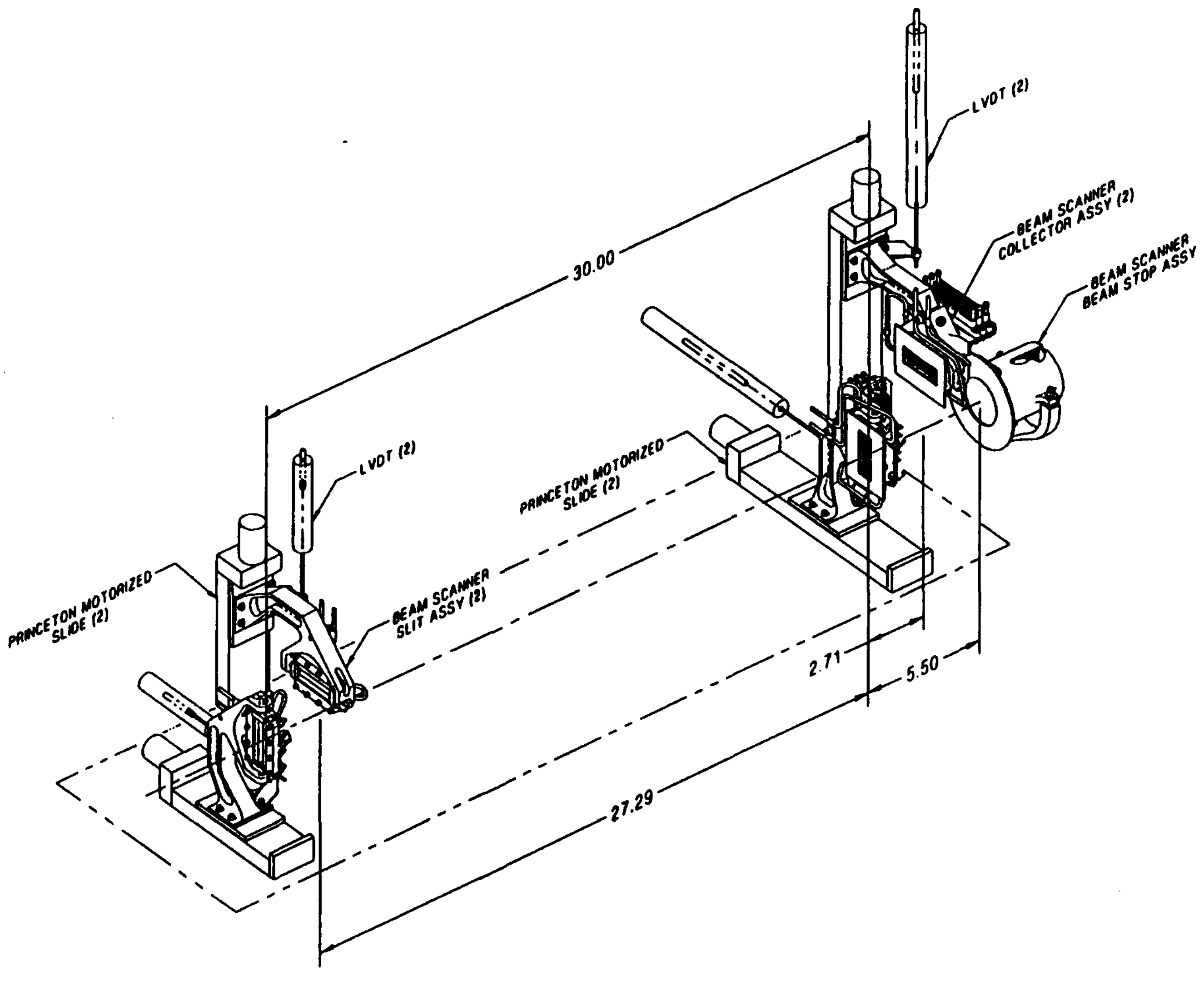
	CURRENT TOROID		DIPOLE
	RF STRIPLINE	THR	TWO HOLE REBUNCHER
	QUADRUPOLE	DEF	DEFLECTOR
		R	ONE HOLE REBUNCHER

Preliminary List of Beam Diagnostics for TBF

Diagnostic	Location	Purpose
Toriod (One in each beam)	Downstream of Q1	Measures the beam current. This is designed to be calibrated in place.
SL-1 (One in each beam)	Downstream of Q3	Monitor alignment of RFQ and the begining of beam.
SL-2 (One in each beam)	Downstream of Q7	Monitor alignment of beam through rebuncher; used to set the phase of rebuncher.
SL-3 (One in each Beam)	Downstream of Q9	Monitors alignment of beam through dipole section; used to set phase of THR and relative energy of beam.
SL-4 & SL-5 (One each for whole sys)	Downstream of Q11 and deflector	These are common to both beams.
Beam Scanner	Located in various places during experiment.	Measure beam location, direction, profile and emittance.

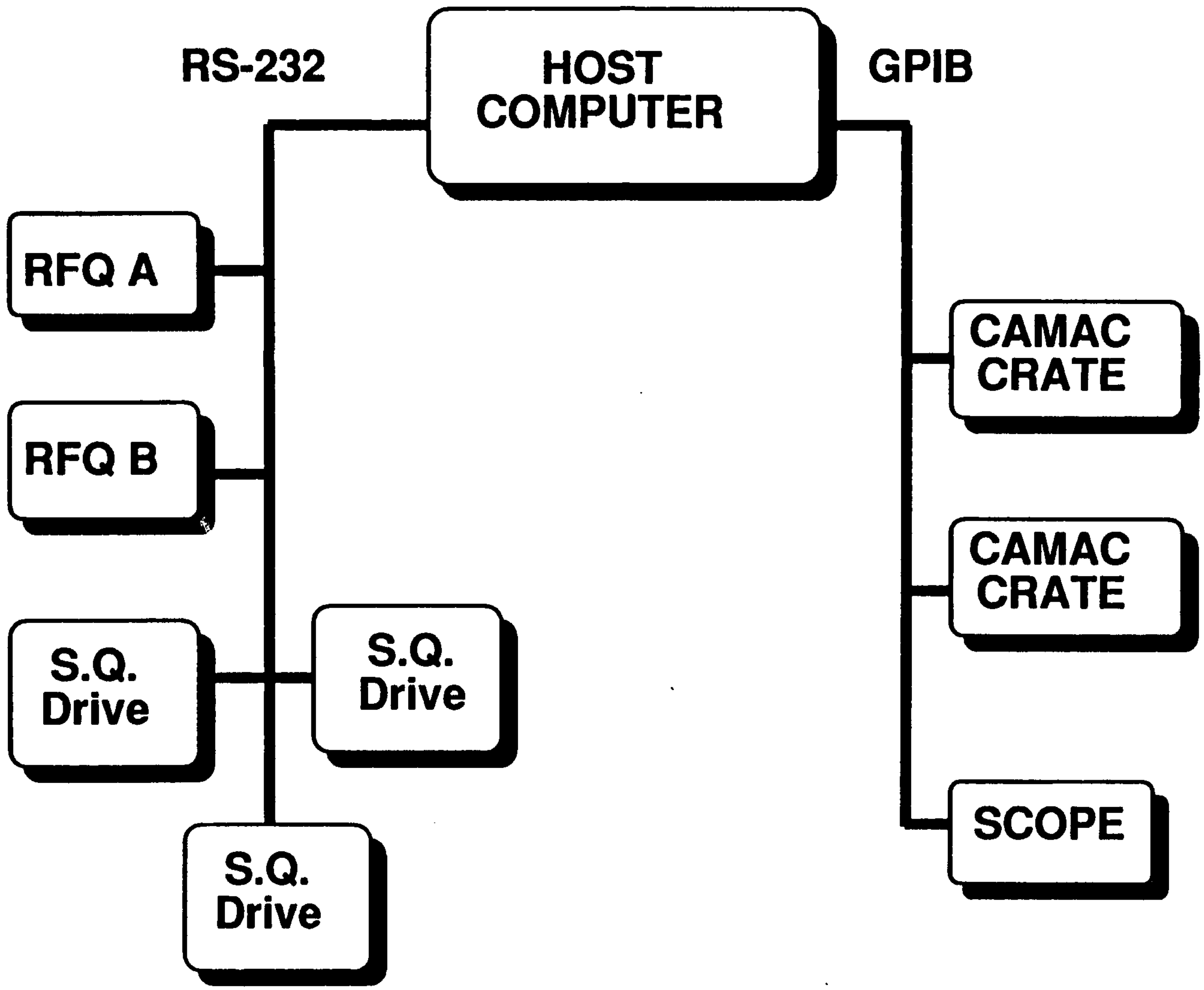
BEAM SCANNER DIAGNOSTICS ASSY

21 SEPT 89

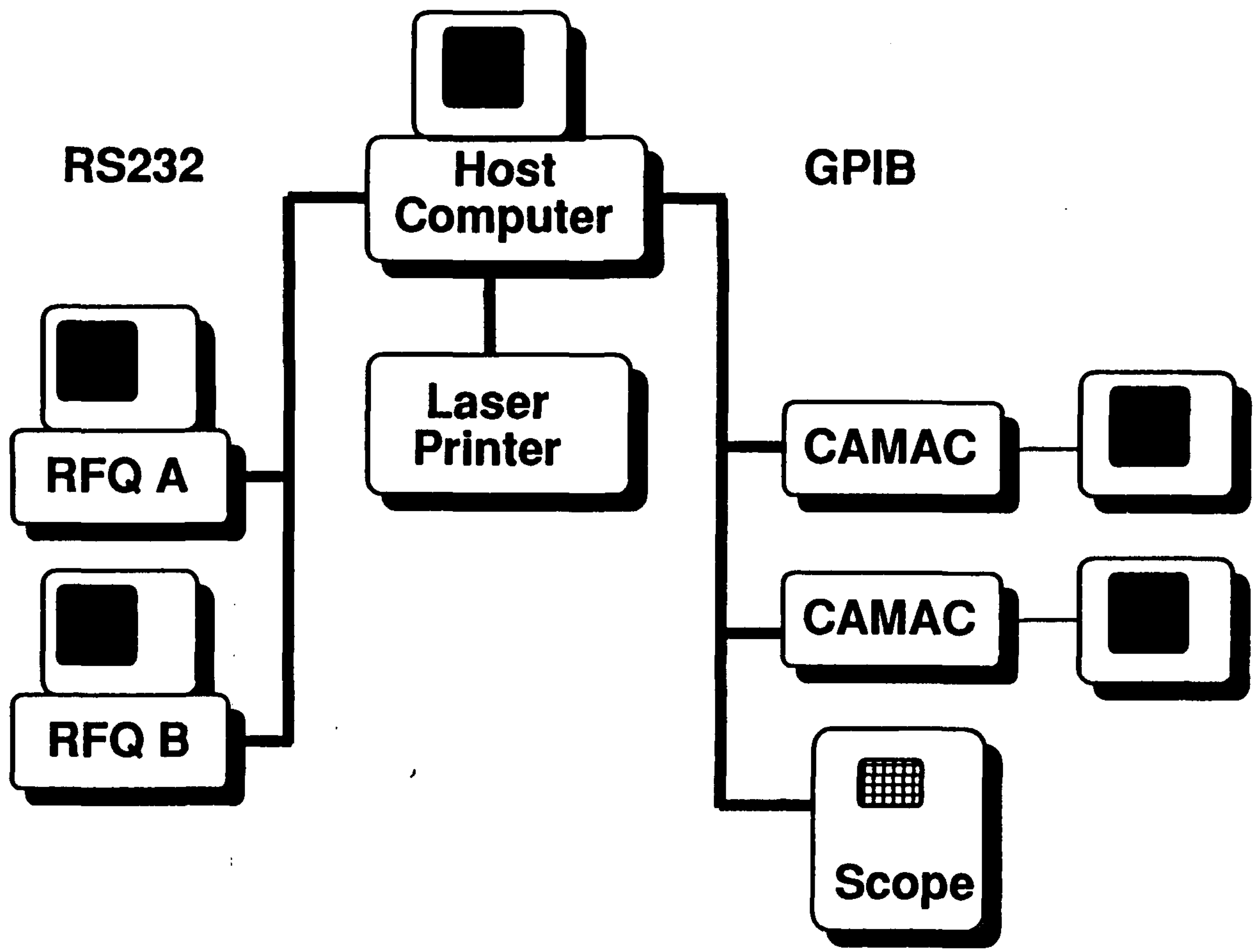


Host Computer Functions, Code Overview & Analysis Functions

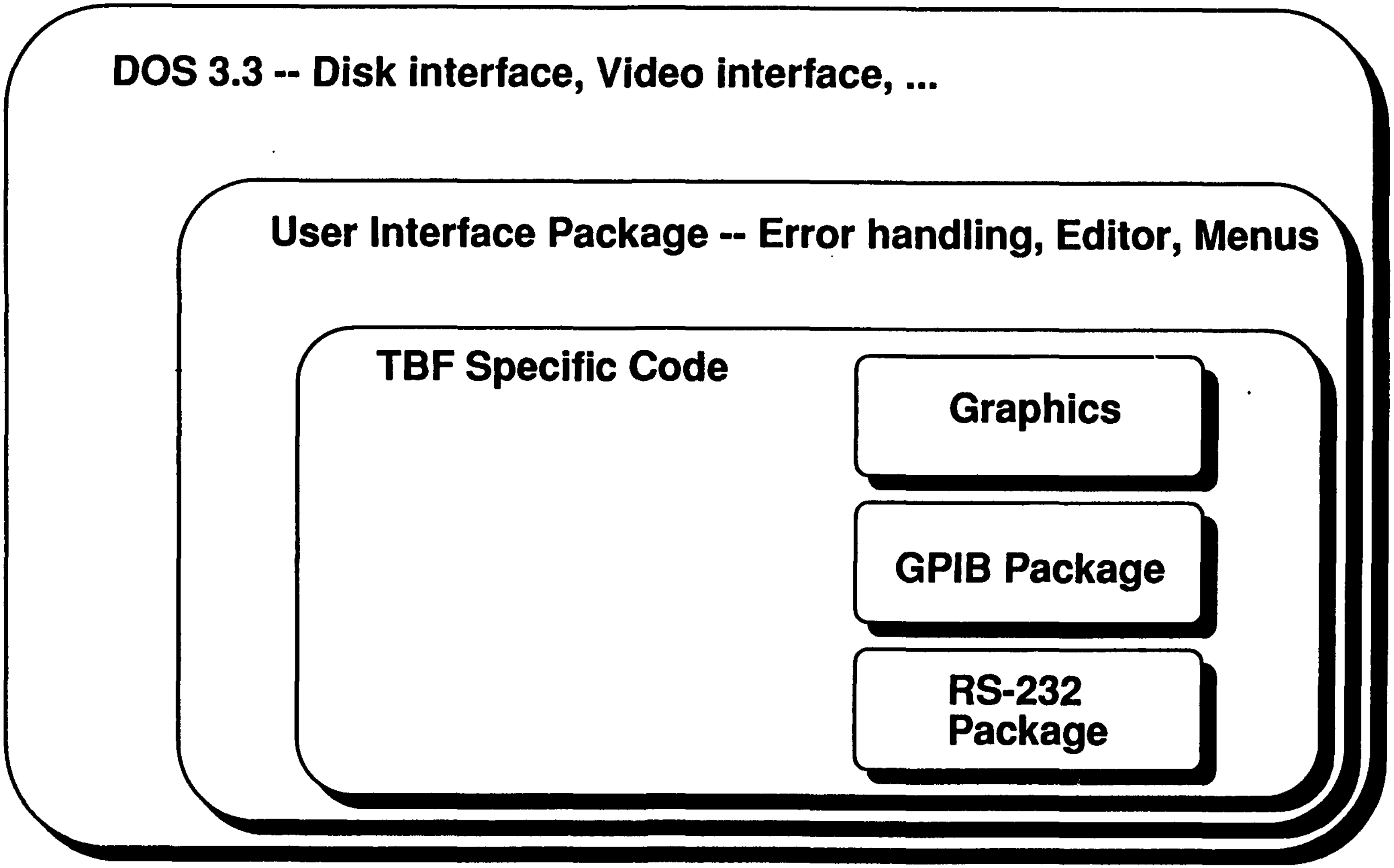
Host Computer Interconnections



Real Time Data Display



Software Overview on Host Computer



Functions of Host Computer

- Control the data collection functions of the LeCroy 6010's, control the timing module program, control the placement of the slides on the beam scanner, collect data from the RFQ control computers, operate the motors for the steering quads, archive experimental data and print a standard report on experiments.
- Log data into files for later analysis on the host or other computer. Data from the CAMAC crates as well as data from the RFQ computers will be logged.
- Under operator control, analyze data just taken or analyze data from a data file.
- Provide on line calibration services for the toroids.
- In a seperate program, provide calibration services for the beam scanner's plate circuits.

Structure of Code on Host Computer

- Code will be table driven. The operator will be able to edit the tables from inside the code to modify the operation of the experiment.
- The tables include: notes, system configuration table,stripline connectivity table, beam scanner table,timer sequencer table and scope table.
- All tables will be included in the archived data file.
- Tables can be saved to disk so the code can have several configurations on hand. The operator will be saved the problems of entering several different code configurations.
- Host computer will be able instruct the 6010's on how to modify the experiment sequencer, the motor drivers, on what data to collect and what data to send back.

Interaction of Host Computer and Operator During the Experiment

- Operator edits the required data tables, selects the experiment, dials in the number of shots and tells the system to go. The operator will then be able to view some of the data in real time on the host computer, view data on the monitors operatored by the intelligent controllers, view data on the scope and decide to allow the process to continue or stop.
- After the experiment the data is transmitted from the CAMAC crates, the RFQ control computers, and, optionally, from the scope to the host computer. The operator can then look at the data and request data analysis such as emittance calculation, calculation of the beam location and direction, toriod current plots, plot stripline data and plot beam profiles.
- The operator can choose to save the data. In which case the host computer will assign a file name, build the file and send it to disk. The data file will include facility data, and control tables needed to reconstruct the experimental situation later.

Analysis Functions of Host Computer

- Data retrieval from archived data.
- Allow user to view the data on command. This includes generating graphs on the screen and on the printer.
- User can append notes onto his copy of the data file but the user will not be allowed to modify the notes taken at the time the experiment was done. The user cannot modify the archived data.
- The code will also break out the data in a file in ASCII format for use on other computers. The files will include a system configuration file, stripline connectivity data, ...
- Code will also write a standard report for the file.

Emittance Calculation

- Use statistical method, i.e. calculate the moments of x and x', and then combine the moments to get the RMS emittance.
- The normalized current distribution will be used to draw a set of contours in current density space to give a visual connection with the optical design calculations.
- The same set of data will also be used to calculate the beam location and beam direction.

Analysis of Archived Data

- The archived data is stored in sequentially numbered files. The files, after being once written are marked as read only to prevent accidental deletion and modification.
- Notes can be added to the file but not saved back to the same file name. Once modified the person using the file must keep a seperate copy to keep the modifications.
- Archived data can be analyzed and displayed in the same ways as before the data was sent to file. Another standard report can be written.
- The code will be able to rewite the data to another set of files in ASCII to allow us to use other computers and codes to analyze the data. In this process the various data tables and configuration tables will be written to seperate files.

CAMAC Modules
Used in Data Collection

Functions of LeCroy 6010

- Collect data from modules in its crate, tell host, via a service request, that data is ready and, upon request from the host, send the data to the host.
- The 6010 can also reprogram the timer sequencer on command from the host computer. The host will send a new pulse list and the 6010 will generate the data for the new timing sequence.
- The data collecting code on the 6010 can be modified by the host computer. The data collection code on the 6010 is run via a table so the host only has to tell the 6010 that a new program is coming and then send the data.

Software Overview on Intelligent Crate Controllers

LeCroy 6010 Operating System

GPIB Interface
Graphics Interface
CAMAC Bus Interface

TBF Specific Software

6010 Software Functions

- Set up modules in crate, collect data from modules in crate on LAM, display data on monitor and return data to host computer on request.
- Down load program to timing module. In one case down load the program to be timing master for experiment and in the other case to operate the slides on the beam scanner.
- Operate system for a specific number of pulses per experiment. When all the pulses for an experiment are done, or a specified number of pulses are done then issue a SRQ to request host to up load the collected data.

Timer Sequencer
Jorway 221 and 222

- Outputs a 12 bit word.
- Timing steps 1 microsecond or 10 microsecond steps. Can control timing sequences longer than 16 sec. Uses 24 bit timer word.
- Allows up to 1024 steps.
- One set of 221 and 222 controls the experiment and the other controls the stepper motors.

LeCroy 8212A's Collects Beam Scanner and Facility Data

- The 8212A's are 32 channel 12 bit ADC's.
- Two will be used to collect Beam Scanner data; 50 channels will be used to look at the plate data. The other channels will look at the LVDT's on the slides.
- The other 8212A will be used to collect facility data.

Jorway Auroura 12's

- Six channel ADC's. Collect data at up to 100ks/sec on 6 channels.
- Will be used to look at the 6 striplines in the individual beam lines and at the data from the toriods.
- With 100 microsecond pulses should get 10 points during the pulse.

LeCroy 6810's

- Fast 4 channel ADC's. When using 4 channels will sample at 1 million samples per second.
- There will be two of these. In the final phase of the experiment each will look at the output of the striplines in the merged beam line. There will be 4 outputs from these signal conditioners: a x-position, a y-position, a 425MHz phase and a 850 MHz phase.
- During the earlier phases they will be used to take a closer look at the other striplines. This is one reason for the code being table driven. The operator can specify which stripline signal goes to which channel of which CAMAC module with out the operator having to keep track of the switch in his note book.

Kinetic Systems 3471

- Digital input unit that detects contact closures.
- Will be used for status switch checking on the various switch yards and flow switches.

Experimental Procedures

Outlines of Specific Procedures

- The following viewgraphs are outlines for the routine measurements required in this experiment. These routine measurements consist of measurement of the beam profile with the slit and beam stop; measurement of the signals from the striplines; and emittance measurements.
- Data from the emittance measurements are used to calculate the emittance, beam location, beam direction, and to plot density contours for comparison with the distributions calculated in the optical design phase.

Beam Profile
Slit and Beam Stop

1. Code moves unwanted slides out of beam and moves the selected slit to its initial position.
2. Code starts the system timer-sequencer which sends timing pulses to turn on RF, request a beam pulse, start the ADCs, stop the ADC's and collect the data from the beam stop current circuit.
3. Code then collects data and sums the data in preparation for taking an average. The returns to step 2 for the requested number of pulses.
4. The code then moves the slit and repeats steps 2 and 3.
5. After measurements at the requested slit positions the code will then, at the option of the operator, display the profile for the selected slit.
6. By request the code will repeat the procedure for the other slit.
7. Code will build the data file, assign a file name, write it to disk and enter the file name in the summary file.

Measure Emittance

1. Clears unwanted slides.
2. Moves selected slit and collector to their initial positions.
3. Code starts time-sequencer, ...
4. Examine distribution of charge on the collector. If beam centered will enough on the collector then go to the next step; modify the collector table if needed. Otherwise calculate a new collector position and repeat steps 3 and 4. If beam too wide for the collector at this point the operator will have to decide to ignore the problem or measure the distribution in steps.
5. Move slit to new location and repeat steps 3 and 4 as often as needed.
6. Operator can then choose the view data is several ways: as emittance parameters, as beam location and direction, beam profiles, and as density contours.

How the Procedures Can be Varied

The code will be table driven to allow the operator maximum flexibility in choosing the limiting parameters for a given procedure.

To change the operation of the system the operator will, in most cases, edit a table of parameters to change the operation of the code.

Table Edit Procedure

- Selected table is displayed.
- Operator edits table. A change flag is set so code can rebuild the internal tables accordingly.
- Tables can be saved on file; default tables can be changed; saved tables can be retrieved and used in the code.
- Tables used in a data run are saved in the data file.
- Tables can be built "off line" with ordinary an ASCII editor.
- All of the following tables will be saved in the data file.

Control Tables

- System Configuration Table -- Keeps track of the components mounted in the experiment at any given time.
- Signal Table -- Keeps track of what signals go to what signal conditioning module and then to what CAMAC crate.
- Timer Sequencer Table -- Controls the timer pulses for the system.
- Stripline Table -- Allows the operator to refer to the stripline signals by name and have the code know where the signals are stored. This lets us move stripline signals around from a slow ADC to a faster ADC.
- Beam Scanner Table -- Controls the initial position, step size and number of steps for a slit. Collector locations are driven by an internally maintained table based on the location of the slit.

EXPERIMENT PLAN

BILL ARD

21SEP89
TBF055.FDR

TBF EXPERIMENT PLAN

MAJOR OBJECTIVE

- DEMONSTRATE INCREASED BEAM BRIGHTNESS FROM FUNNELING BEAM FROM TWO SEPARATE ACCELERATORS

OTHER OBJECTIVES

- EVALUATE CONTRIBUTION TO EMITTANCE GROWTH DUE TO THE RF DEFLECTOR
- EVALUATE EFFECTS OF REBUNCHING ON CONTROL OF EMITTANCE GROWTH
- EVALUATE USE OF STRIPLINE POSITION AND PHASE DETECTORS FOR USE IN AUTOMATIC CONTROL OF FUNNEL PARAMETERS

MAJOR TBF EXPERIMENTS

EXP. I - ASSEMBLY,TEST AND OPERATION OF THE TBF FUNNEL, DIAGNOSTICS AND DATA ACQUISITION SYSTEM

EXP. II - MATCHING ACCELERATOR A TO FUNNEL

- ALIGNMENT OF BEAM IN FUNNEL
- PHASE SETTINGS FOR REBUNCHERS
- PHASE SETTINGS AND CALIBRATION OF DEFLECTOR
- EMITTANCE OF BEAM A WITH AND WITHOUT POWER IN DEFLECTOR

EXP.III - SIMILAR TO EXP.II FOR BEAM B

EXP.IV - MERGING OF THE A AND B BEAMS

- ADJUSTMENT OF PHASE AND ENERGY OF BEAM B
- TRIMMING OF MOVABLE QUADS FOR MAXIMUM OVERLAP
- MEASUREMENT OF CURRENT AND EMITTANCE OF BEAM A, BEAM B AND BEAM (A+B)

21SEP89
TBF057.FDR

SUPPLEMENTARY TBF EXPERIMENTS (UNSCHEDULED)

EXP.V - CHARACTERIZATION OF STRIPLINE OUTPUTS FOR OFF-NOMINAL BEAM CONDITIONS

- MEASUREMENT OF STRIPLINE OUTPUTS WITH OFF-NOMINAL PHASE SETTINGS FOR A AND B BEAMS
- MEASUREMENT OF STRIPLINE OUTPUTS WITH OFF-NOMINAL SETTINGS OF DEFLECTOR VOLTAGE
- MEASUREMENT OF OUTPUTS WITH MOVEMENT OF MOVABLE QUADS

EXP. VI - MEASUREMENT OF THE A AND B ACCELERATOR OUTPUT BEAM EMITTANCES

EXPERIMENT I

ASSEMBLY AND TEST OF TBF FUNNEL

REQUIREMENTS: ALL FUNNEL COMPONENTS INCLUDING DIAGNOSTICS PREVIOUSLY BENCH TESTED AND CALIBRATED

PURPOSE OF TEST: VERIFY OPERATIONAL INTEGRITY OF COMPLETE EXPERIMENTAL SYSTEM AT FULL RF POWER

EXPERIMENT I ELEMENTS

I.a VACUUM TEST OF COMPLETELY ASSEMBLED SYSTEM, ELECTRICAL TESTS OF ALL CABLES, CONNECTORS, ETC., OPERATION OF STEPPER MOTORS.

I.b ELECTRICAL TEST OF RF LEADS, WINDOWS, PHASE AND AMPLITUDE OUTPUTS AND CAVITY TUNING AT FULL RF POWER.

I.c MEASURE AND REDUCE, IF NECESSARY, RF PICKUP IN DIAGNOSTIC CIRCUITS AT FULL RF POWER.

I.d ALL-UP TEST OF RF CONTROLS FOR FREQUENCY, AMPLITUDE AND PHASE.

I.e ALL-UP TEST OF DATA ACQUISITION SYSTEM.

EXPERIMENT II

A - INPUT BEAM THROUGH FUNNEL

REQUIREMENTS: A-ACCELERATOR INSTALLED IN LAB AND OPERATING WITH GOOD BEAM. COMPLETED FUNNEL CHECKOUT.

PURPOSE OF TEST: VERIFY THE OPTICAL QUALITY OF THE BEAMLINE, THE FUNCTION OF THE RF SYSTEMS AND THE QUALITY OF THE BEAM AT THE FUNNEL OUTPUT

EXPERIMENT II ELEMENTS

II.a VERIFY ALIGNMENT OF A-BEAM WITH FUNNEL INPUT.

II.b ALIGNMENT OF BEAM WITH THE RF DEFLECTOR USING MOVABLE QUADS.

II.c RB1A AND RB2A PHASES SET FOR CORRECT ZERO CROSSING.

II.d RF DEFLECTOR PHASE SET FOR MAXIMUM DEFLECTION AND DEFLECTION ANGLE vs. DEFLECTOR POWER MEASURED.

II.e EMITTANCE MEASUREMENT OF BEAM 'A' WITH AND WITHOUT DEFLECTOR POWER AND AS A FUNCTION OF REBUNCHER POWER.

EXPERIMENT III

B - INPUT BEAM THROUGH FUNNEL

REQUIREMENTS: B-ACCELERATOR INSTALLED IN LAB AND OPERATING WITH GOOD BEAM. A-BEAM EMITTANCE WITHIN ACCEPTABLE LIMITS AT FUNNEL OUTPUT

PURPOSE OF TEST: VERIFY PERFORMANCE OF THE B-LEG OF THE FUNNEL AND DETERMINE THE QUALITY OF THE B-BEAM AT THE FUNNEL OUTPUT

EXPERIMENT III ELEMENTS: SAME AS EXPERIMENT II ELEMENTS

EXPERIMENT IV

MERGING OF TWO BEAMS

REQUIREMENTS: 1. $\theta_A = -\theta_B <= \Delta\theta(max)$, $\Delta\theta(max)$ IS THE MAXIMUM BEAM DEFLECTION THAT THE RF DEFLECTOR CAN PRODUCE WITH THE AVAILABLE, OR USABLE, DEFLECTOR POWER

2. $\varepsilon_A \equiv \varepsilon_B <= \varepsilon_{acc} + 40\%$

THESE CONDITIONS MUST BE MET FOR THE FUNNELED BEAM TO BE BRIGHTER THAN THE ACCELERATOR OUTPUT BEAM.

PURPOSE OF TESTS: INVESTIGATE DETAILS OF PHASE, ENERGY AND POSITION ADJUSTMENTS REQUIRED TO TUNE THE FUNNEL FOR MAXIMUM OVERLAP IN PHASE SPACE OF THE TWO BEAMS AT THE FUNNEL OUTPUT

EXPERIMENT IV ELEMENTS

IV.a ADJUSTMENTS OF FUNNEL A-LEG PARAMETERS AND RF DEFLECTOR TO PLACE A-BEAM ON FINAL AXIS

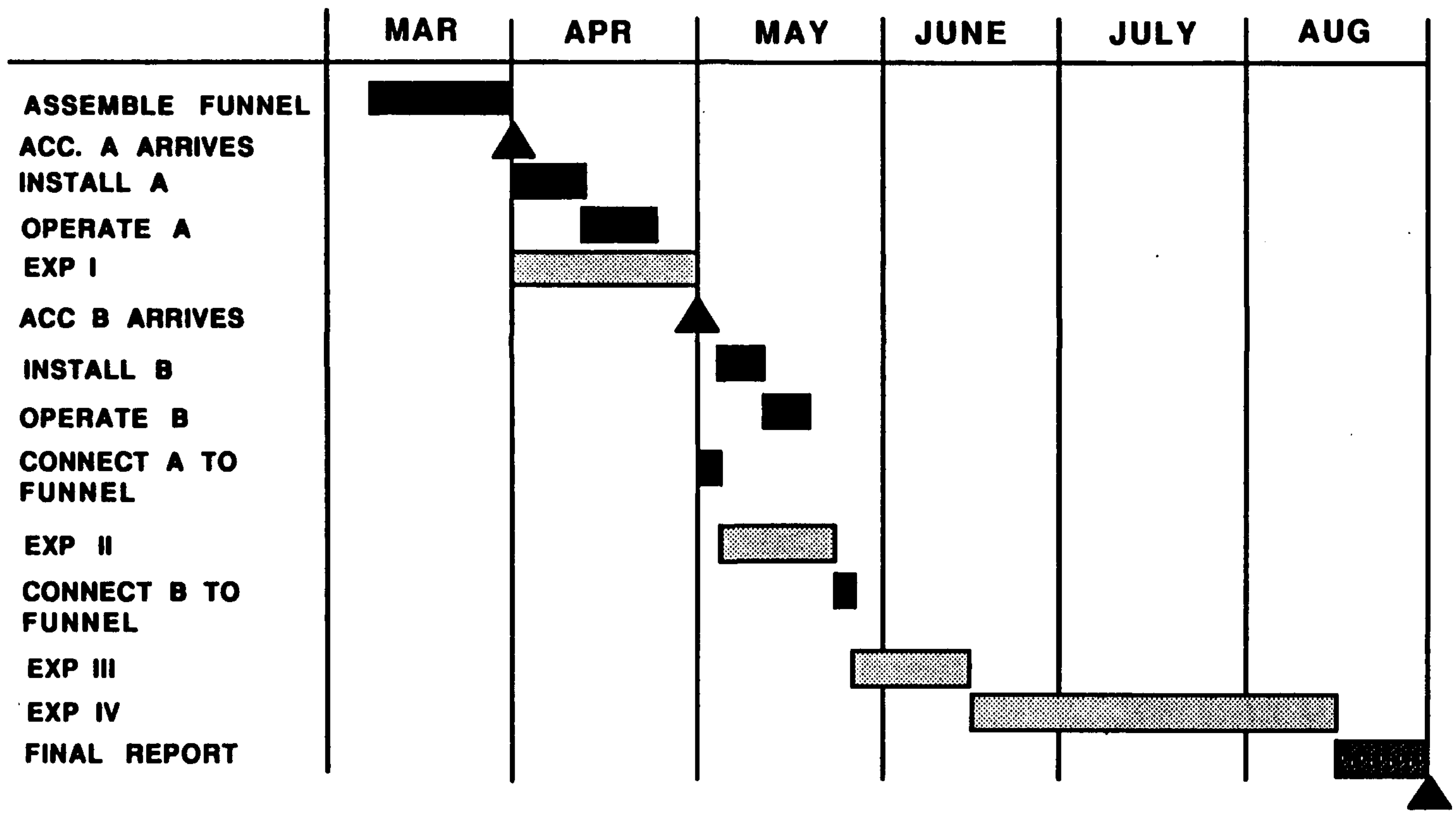
IV.b MATCHING PHASE AND ENERGY OF BEAM B TO A. (THE A-BEAM IS THE REFERENCE TO WHICH THE PHASE OF THE TWO-HOLE REBUNCHER AND THE DEFLECTOR ARE SET).

IV.c MERGER OF THE BEAMS AND FINE ADJUSTMENTS FOR MAXIMUM OVERLAP.

MEASUREMENT OF EMITTANCES OF BEAM A, BEAM B AND BEAM (A+B).

21SEP89
TBF106.FDR

TBF EXPERIMENT SCHEDULE



McDonnell Douglas Missile Systems Company